

BOT FRAMES AND POWER TRAINS • BBIQ SPECIAL FEATURES

BATTLEBOTS®

SUMMER 2002:

VOL III

MAGAZINE



BATTLEBOTS IQ TOURNAMENT RESULTS

MAKING THE TEAM

A Close-Up on the Builders of Team SHENBOT

LIFE IN THE PITS

Photo Gallery of the Pit - Season 5.0

BREAKING DOWN THE BOTS

A look under the cover of four BBIQ contenders
and the dissection of a BattleAnt.

Plus:

Full Page Action Shots
Comments From The Judge's Bench
BattleAnt Tournament Coverage

BATTLEBOTS



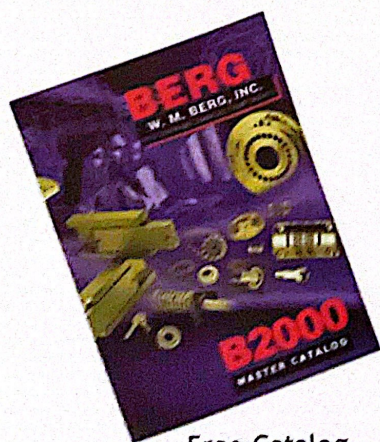
EDITION





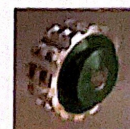
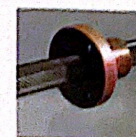
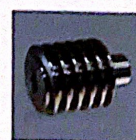
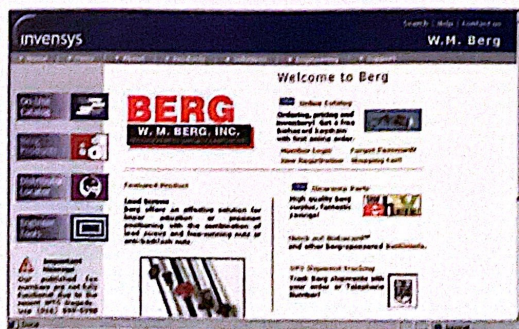
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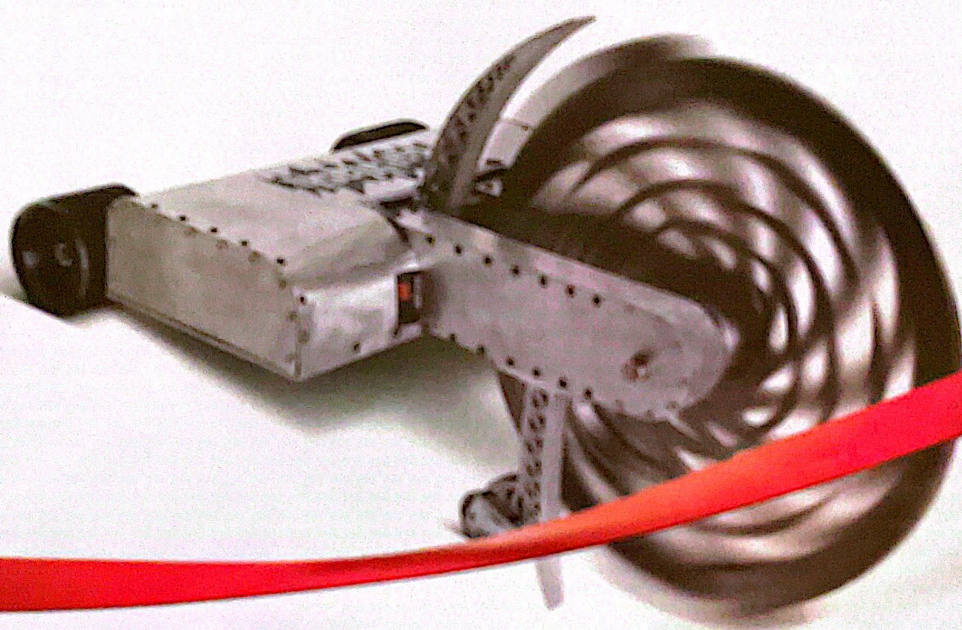
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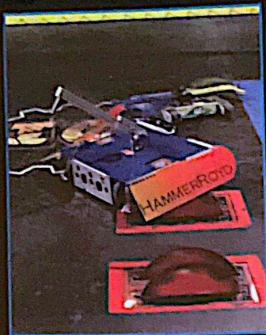
How would you like a place where you can enjoy the taste of great food, and the taste of victory all in one sitting? At the Lazy Toad Robot Club, we plan on satisfying both of your tastes daily. The grille and the games are on for the Summer of 2002 in Pittsburgh, PA. Visit LAZYTOAD.com for details.



Lazy Toad Robot Club

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SUMMER 2002



On the Cover. HammerRoyd (bottom), an Oneida Technology Student Association creation, used its pneumatic pick to peck its way past competing schools' defense systems. HammerRoyd's impressive technical entourage included a group of 38 enthusiastic students and advisors. The horizontal spinning mass of the robot Green Wave (top) had the ability to disable its opponent with a single blow. Most unfortunate for Green Wave, a harsh lesson in Newton's Third Law of Motion was dealt at each victory. Paul Ventimiglia, a student from the Delbarton School, would often gather the remains of Green Wave then gather support from eliminated teams to cumulatively rebuild Green Wave time and time again for a very impressive struggle.

- Photo by Daniel Longmire

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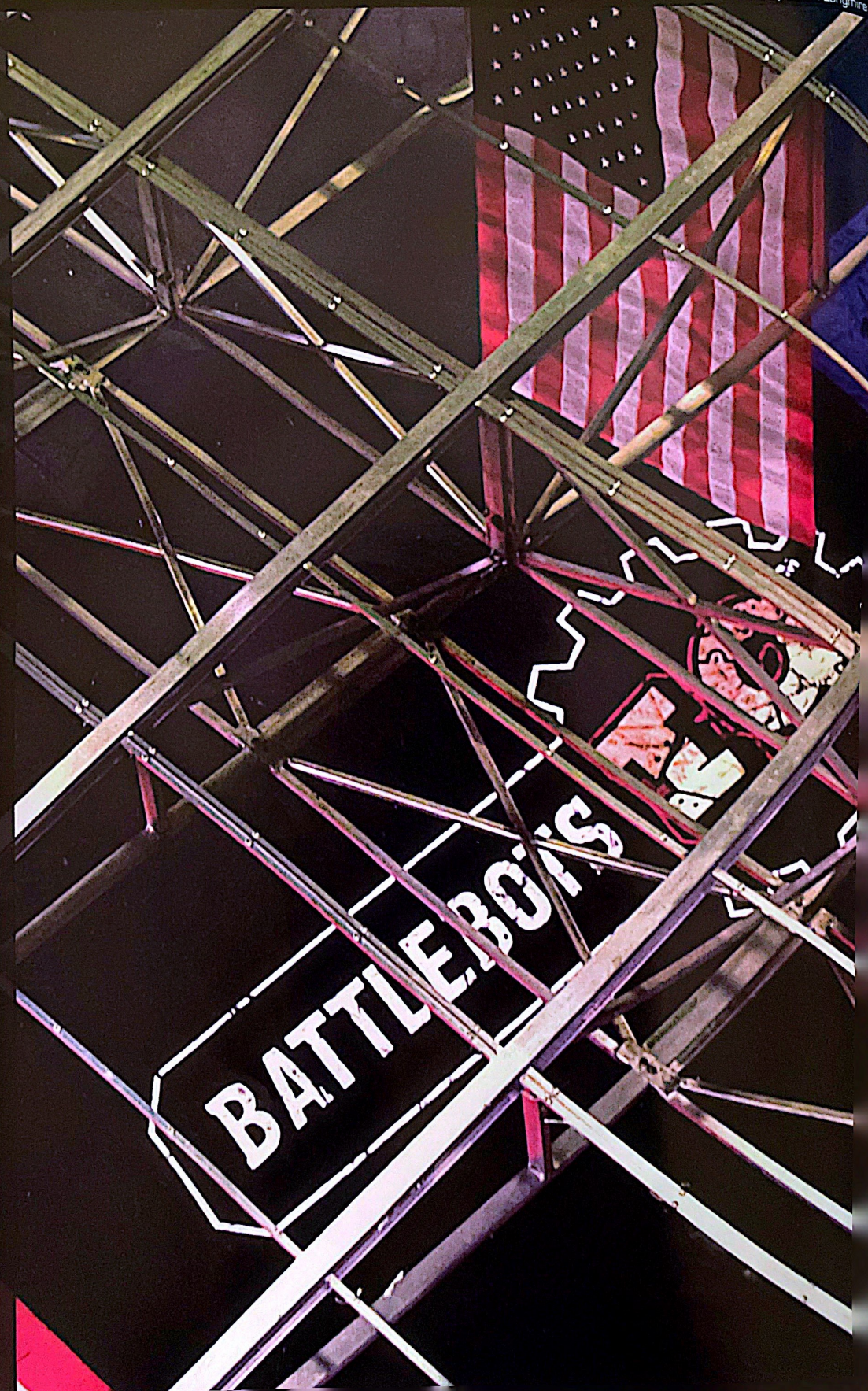
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Photographers
Daniel Longmire
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Merchandising/Subscriptions
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The BattleBots IQ Tournaments is a new national robotics competition open to Middle and High School Students ranging from 12 to 18 years of age.

In the future, BattleBots IQ Tournament will serve as the official interscholastic competition for schools participating in the BattleBots IQ Curriculum, which is currently being implemented in high schools across the United States.

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Turbo	Deadblow	Atomic Wedgie
Whirligig	Rammstein	and 1000's more . . .



Over 13931 Sold

Bots and Brains.... a Smart Combination.

Bots and brains work well together...it's fingers, faces and eyes we want to be careful about.

Photography By:
Daniel Longmire, Roy Hellen

The Formula for Success is Clear: Focus the Passion

Creativity and passion are the currency of youth, this is what they trade for experience.

Kids are passionate and active learners, and they are ceaseless inventors. High School students **want** and **need** stimulating and engaging opportunities for personal growth and achievement. They willingly accept challenges and they succeed at complex activities requiring sustained commitment and high levels of concentration.

Kids willingly accept the risks and rewards of achievement. Remember, the coaches are on the sidelines during the game.

Sports is an Avenue for Achievement

To be good, you have to practice. It's a great lesson for life.

High School sports programs provide the kind of opportunities kids enjoy. High School athletes accept responsibility, enjoy the results of commitment and concentration, work together and recognize their ability to succeed.

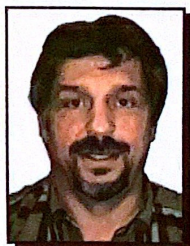
At the start of the 2nd millennium, the United States of America held 768 Olympic Gold Medals. This number exceeded the combined Gold medal holdings of the 2nd, 3rd, 4th and 5th place countries combined!

The U.S. produces many of the greatest athletes and athletic teams in the world because we celebrate athletic achievement on a grand scale. Just look at the facts.

- We invest tremendous time and money in the development and eventual success of our nation's athletes.
- High School athletic programs exist in public and private schools across the nation.
- The achievements and success of high school athletes are chronicled daily in our nation's newspapers.
- As the Olympic record indicates, our nation's investment in athleticism is paying significant dividends.

Imagine if we had academic programs like this!

Michael Bastoni, Professor of Science and Technology at Plymouth North High School in Plymouth, Massachusetts. Professor Michael Bastoni is the author of the BattleBots IQ Curriculum.





Ironic, isn't it?

Maybe we don't practice enough.

America leads the world in athletic prowess, political influence and corporate capitalization, yet it has to hire foreign nationals to meet the scientific and engineering needs of this nation.

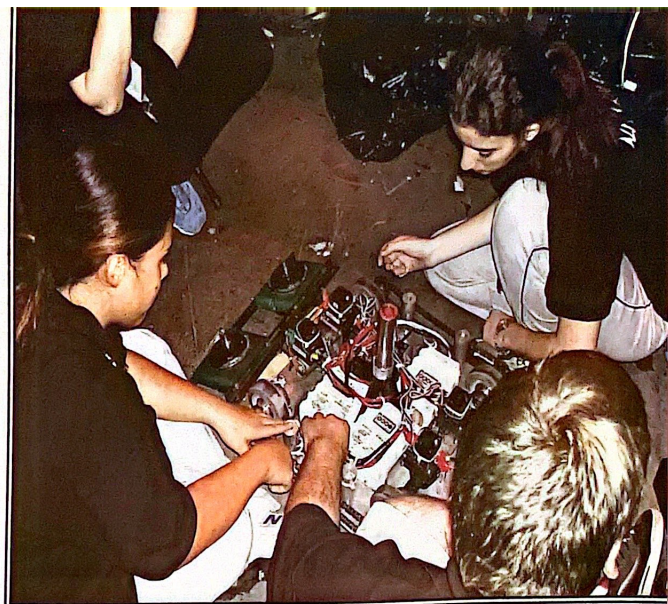
Here is an excerpt from the Third International Mathematics and Science Study (TIMSS) website.

<http://nces.ed.gov/timss/timss95/more.asp#how>

How did the United States perform on TIMSS?

U.S. students scored above the international average in both mathematics and science at the fourth-grade level. At the eighth-grade level, U.S. students performed above the international average in science and below the international average in mathematics. In the final year of secondary school (twelfth grade in the U.S.), U.S. performance, including among our most advanced students, was among the lowest in both science and mathematics.

The implication is clear: we need programs that emphasize the importance and rewards of developing academic skills, in the same way that high school sports emphasizes athleticism.

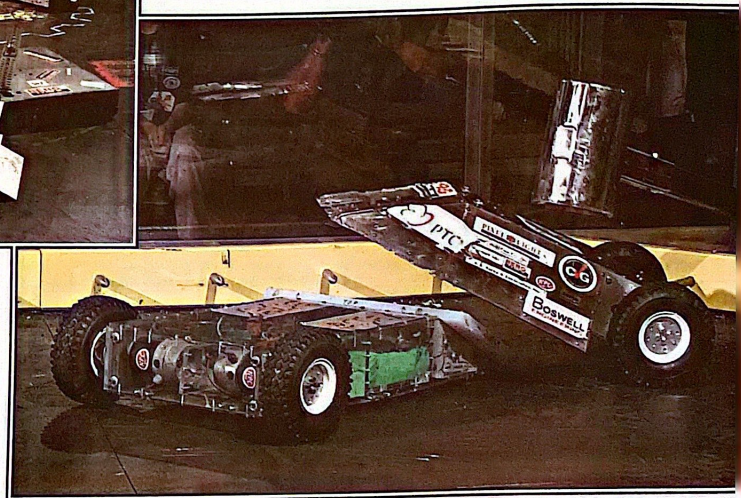
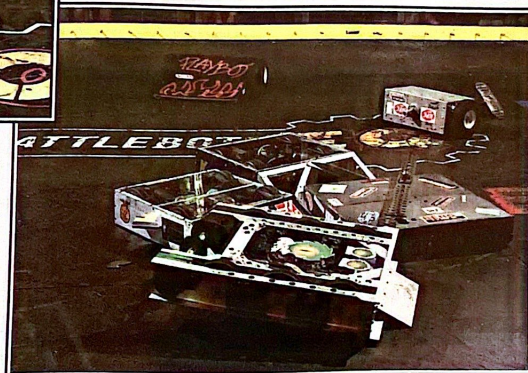


Imagine This....

What if we could create programs in which kids accepted the responsibility of knowing and doing the things they learn in school in order to win "The Game"?

What if we could apply the success of the sports model to academic subjects?

Imagine what would be possible if we developed exciting, engaging and creative games for the mind? Think about team games that, instead of running, jumping or throwing, practices included thinking really hard, being creative, and inventing new ways to do new things.



What if schools had gymnasiums for the mind where techno-athletes could work out...could exercise their minds and develop the skills necessary to create new worlds of knowing, doing and understanding?

What level of student achievement would be possible if we could create a reason to do this? A reason as compelling and rewarding as playing a sport?

What if a team's ability to weld and grind and hammer their ideas into reality really existed? What if understanding torque curves, using trigonometry tables, fabricating high tech materials and managing power and energy improved their chances of becoming national champions?

Would they do it?.....Could they?

Well, they can, and they already have. On March 25th 2002, 47 teams from across the nation met for the first time to decide the BattleBots IQ national champion and they had a great time doing it.



Now you can be one of them.

Let Me Paint A Picture

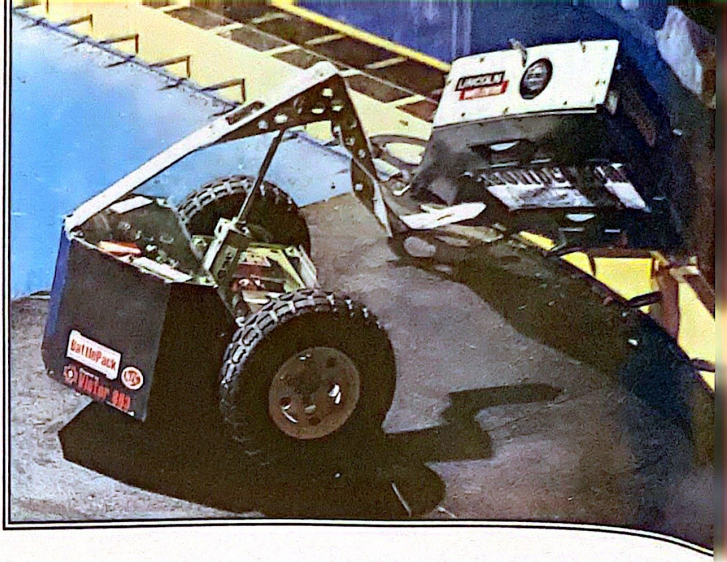
Significant innovations often have humble beginnings.

Think Sports, Think NBA

December, 1891: James Naismith nailed a peach basket to a balcony railing at Springfield College and created the game of basketball. A major league professional sporting event is born.

Think High Tech, Think NASA.

March 16th, 1926, Worcester, Massachusetts: Robert Goddard combines liquid oxygen and gasoline in the world's first liquid fuel rocket. The door to space is opened.



Think Sports and High Tech, Think BattleBots IQ

August 14th 1999, Long Beach University: Trey Roski, Greg Munson and Pete Lambertson erect the first BattleBox. The sport of combat robotics is defined. Science and sports are combined and a national educational initiative is launched.

BattleBots IQ, A Sport for the Mind

Er, no...it's not quite like chess.

BattleBots IQ is a Team Sport

BattleBots is an exciting and engaging engineering contest played on a regulation course, as defined and instantly recognizable as a diamond, a gridiron or a court. And it takes a team to compete. Math, science, engineering, communications skills and knowledge become compelling and creative tools in the hands of Student and Teacher designers.

Designing a BattleBot requires the clear communication of ideas, the management of time, materials and resources, and the maintenance of accurate records; critical life skills that offer advantages to those who develop them. In addition, the knowledge and activities supported by the BattleBots IQ program are mapped to national curriculum standards in Mathematics, Science and Engineering.



BattleBots IQ Is Great Education

BattleBots IQ is a compilation of pedagogical strategies that can enhance the excitement and passion to learn that is generated by the BattleBots competition. At BattleBots IQ, we believe it is important to offer students and teachers a multitude of avenues to express and share what they know and are able to do. We believe the BattleBots high school team benefits from the creation of many "playing" positions. We would like to attract a diverse group of interested and talented students and teachers into the program.



Nola Garcia
BattleBots IQ
Educational Director
nola@BattleBots.com

Making Connections

Learning is an adventure in which the paths of knowledge are all in close proximity and often intersect. Creating a venue that celebrates this cross-pollination of passions provides students and teachers the chance to construct knowledge to make ideas and to develop skills and ways of being that are both personally satisfying and contribute to the BattleBot Team's success.

People gain deeper understanding through personal, passionate and active involvement in the process of thinking and doing. BattleBots offers the catalyst for meaningful engagement in learning, and provides avenues by which people can share what they know and are able to do.



Learn How Your High School Can Participate

High schools across the country are creating design teams and participating in Robot-Sporting events. From Florida to Washington, students and educators are learning how things really work and why they break, as they work to develop the engineering acumen necessary to design and construct BattleBots.

To learn how your high school can become a BattleBots IQ School, logon to www.BattleBotsIQ.com

SO YOU WANT TO BE A CONTENEDER

by Mike Konshak
Team RobotDojo

The first question I'll ask is "What would you rather do, drive one or build one?" If the answer comes back "Drive one, of course. It looks like fun!" then I'll tell you that you are in the wrong sport and you need to stick to buying R/C cars or models made in the likeness of famous robots.

The reality is, for every three minutes of driving these things, you will have spent 3 months working on it, which entails studying, calculating, designing, part selecting, buying, modifying, building, machining, welding, assembling, disassembling (a dozen times or more), wiring, soldering, crimping, screwing...Then, maybe, about two weeks before the big show, you are practicing, followed by repairing weaknesses that you found while driving. If you are not a hands-on type of person, and you don't like to get your hands dirty, or if you do not have close friends and associates who like doing these things for you, again, you are in the wrong sport.

If you are going to get upset because the new thing you just created gets demolished to the cheers and jeers of other bot builders, with a million people looking on, you are probably in the wrong sport.

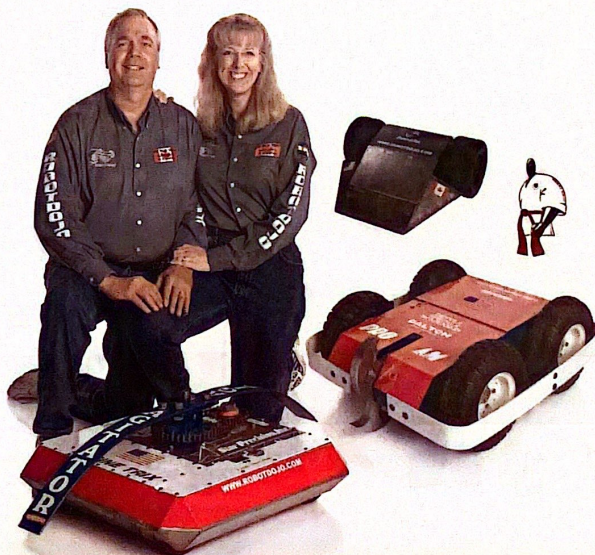
People with eager minds and supportive parents, spouses and friends, who enjoy creating from scratch something that has never been built before, giving birth to new ideas, and learning new skills, find that they have a blast building and competing with combat robots. Especially as an alternative to ball sports! Right now there is no similar venue in which you can be involved that will give you the exposure and visibility that being on BattleBots can offer. Aside from the opportunity to be on a TV show, there are dozens of other competitions all around the continent to which are excellent proving grounds for testing your bot's capabilities. I used to say,

when I raced on the motorcycle circuit, that half the fun is getting there. Traveling around, "seeing the USA in your Chevrolet", is a lot more prestigious than hanging out at your local soccer field or basketball court.

After you have accomplished the building of your bot and actually won a fight or two, you'll find that the engineering skills and trades that you've just developed will help you in your schoolwork or at your job, because the powers that be like having people around them that finish projects that they start.

This is a cool sport for those folks who don't like risking their neck doing extreme sports, or can't throw a ball, or can't go jogging. The star is the robot, and robot builders come in all sorts of shapes, ages, sizes, backgrounds, ethnicities, and professions (but generally technical or mechanical in nature). You could be a pudgy 55-year-old man paired against a 12-year-old girl with pigtails, and you could get your bot trounced just as fast as if you were paired against a muscular jock in a wrestling contest. This is the Bot's element, and with a strong, reliable design and strategy on your side (and a whole lot of luck), YOU can end up taking home the Giant Nut.

Mike and Becky Konshak show off the Fleet of RobotDojo BattleBots: Agitator, Pro-Am, and Wee Willy Wedgie.



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THE TEAMS OF BBIQ MARCH 2002



Accelerator
Plymouth, Massachusetts



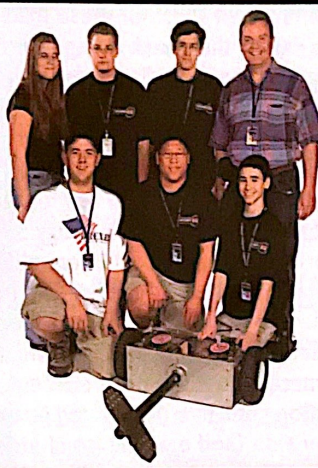
Angry Kitchen Appliance
Manchester, Massachusetts



A-Wreck-No-Bot
Orlando, Florida



Checkmate
Miami, Florida



Deborah
Sudbury, Massachusetts



Default
Plymouth, Massachusetts

Photography By:
Daniel Longmire



Evil Eagle
Hauppauge, New York



Flip
Miami, Florida



Gatorblade
Pearl River, Louisiana



Joan of Arc
Miami, Florida



Kaibosch
South Wales, New York



Karl
Thief River Falls, Minnesota



Kobbotsu
Tipp City, Ohio



Axis
Bloomsburg, Pennsylvania



Baltronic Wedge
Brecksville, Ohio



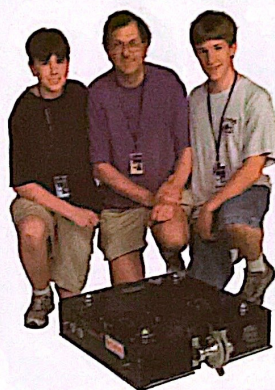
Botsy
Lake Helen, Florida



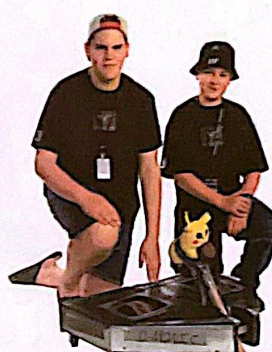
Bulldog Warrior
Pueblo, Colorado



Defenestrator
Columbus, Indiana



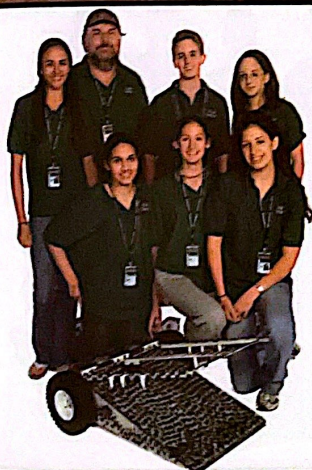
Discombobulator
Arlington, Virginia



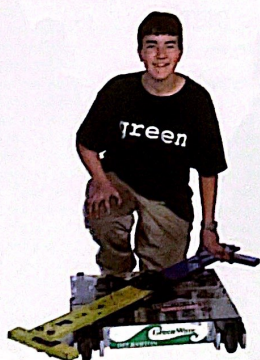
D-Monic
Highland Village, Texas



E2
Hackensack, New Jersey



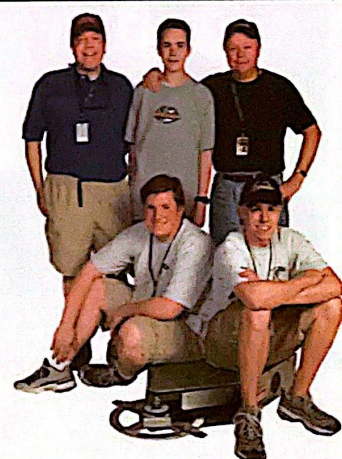
GatorBot
Miami, Florida



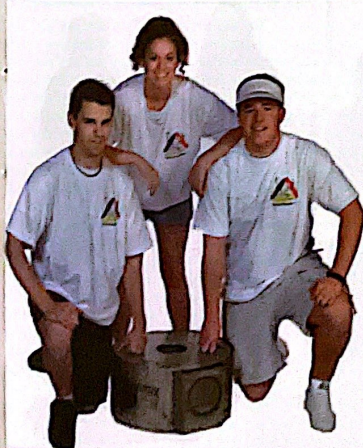
Green Wave
Wayne, New Jersey



HammerRoyd
Oneida, New York



Happy Scrappy Hero Pup
Wilmette, Illinois



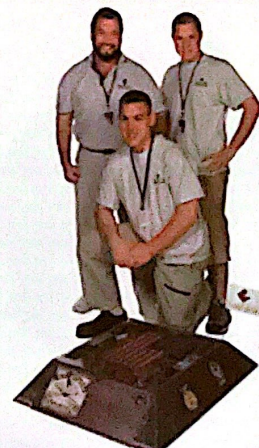
Lethal Dosage
Plymouth, Massachusetts



Lurker
Sarasota, Florida



Mag-ness
Jacksonville, Florida



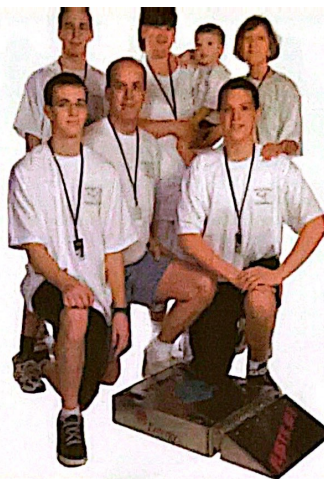
Metal Fury
Brecksville, Ohio



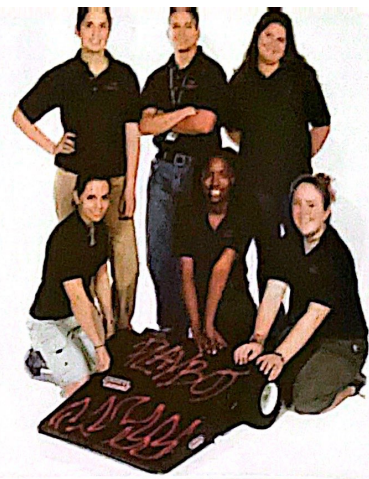
Nightstalker
Miami, Florida



Oblivion
Tampa, Florida



PlasticBot
Plymouth, Massachusetts



PlayBot
Miami, Florida



Plow King
Pueblo, Colorado



Raider
Eden, New York



Reaver
Warwick, Rhode Island



Scorpion
Pueblo, Colorado



Steven Seagal
Pittsburgh, Pennsylvania



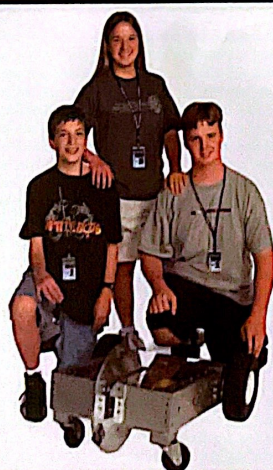
Swiss Cheese the Wedge Bot
Miami, Florida



Tetanus
Pueblo, Colorado



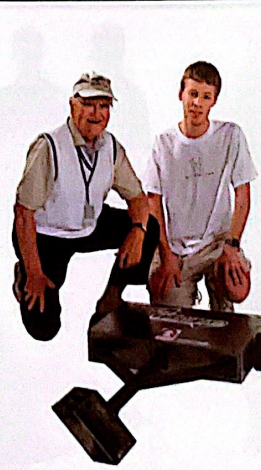
Undertow
New Orleans, Louisiana



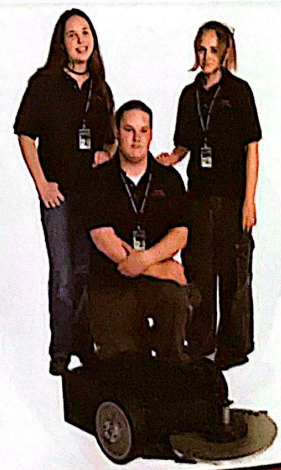
Whambulance
Titusville, Florida



Wee Willy Wedgie
Louisville, Colorado



WhirlWind
Pittsburgh, Pennsylvania



Wut
Miami, Florida

MAKING THE TEAM

A LOOK AT THE BUILDERS BEHIND THE BOTS

-Roy F. Hellen

FEATURING:

When I first observed the various BattleBots IQ contestants at the inaugural competition in Orlando, I was amazed to find a dynamic collection of teams consisting of fully functional cooperative units. The teams were structured internally into sub-groups with each specializing in vital building responsibilities. In spite of this structure, however, I also noticed that the groups would freely help each other out and share responsibilities as well.

I grilled the student teams relentlessly about their robots with questions relating to construction, components, and operation. In every department, including materials acquisition, machining,

mechanical engineering, electronics, and funding, there was a different point person and leader. Each point person then had an entourage of apprentices who were collectively facilitating each project. I was deeply impressed by this structuring of roles and specialties.

During the interviews, I would notice the teachers as well. Like proud parents, they were aglow with admiration for their pupils. These mentors were also content to stand back and allow the students to express themselves through their work. That willingness to fully facilitate the students' path of learning and discovery is one of the hallmarks of the BattleBots IQ experience.

TEAM SHENBOT

Team SHENBot is comprised of students from the Columbus Area Career Connection Technical School (C4) located at Columbus North High School. The students are bussed in from seven separate schools in four different counties. The students' general studies are accomplished at their respective schools, but two to three hours a day are spent at C4 with a Manufacturing Engineering

cluster. Team SHENBot was developed under the direction of C4 teachers Mike Riley, Randy Sims, and Stan Myer. Team SHENBot's creation, Defenestrator, was introduced as a project for the entire C4 facility. Students sign up for only one class (i.e. electronics) but are encouraged to explore other disciplines taught at C4. The BBIQ project gave purpose and desire for students to bridge the gap between different classes.

Craig Smith - BotFrames:

Coordinates the construction of the frame, chassis, and armor. Uses machining and welding techniques to create durable mounts for all systems and protective casings for critical operational components.

Willy Koch - Electronics:

Components research and acquisition. Uses DC theory to calculate maximum current loads for electrical systems. Designs and builds wiring harness within the robot chassis.

Scott Daily - Mouse Jockey:

Computer Graphics expert that provides illustrated feasibility and manufacturing tolerances. Documents project from conceptualization to construction. In training for Production Manager and will assume the position once Elliott graduates.

Jacob Hazelgrove - Armaments:

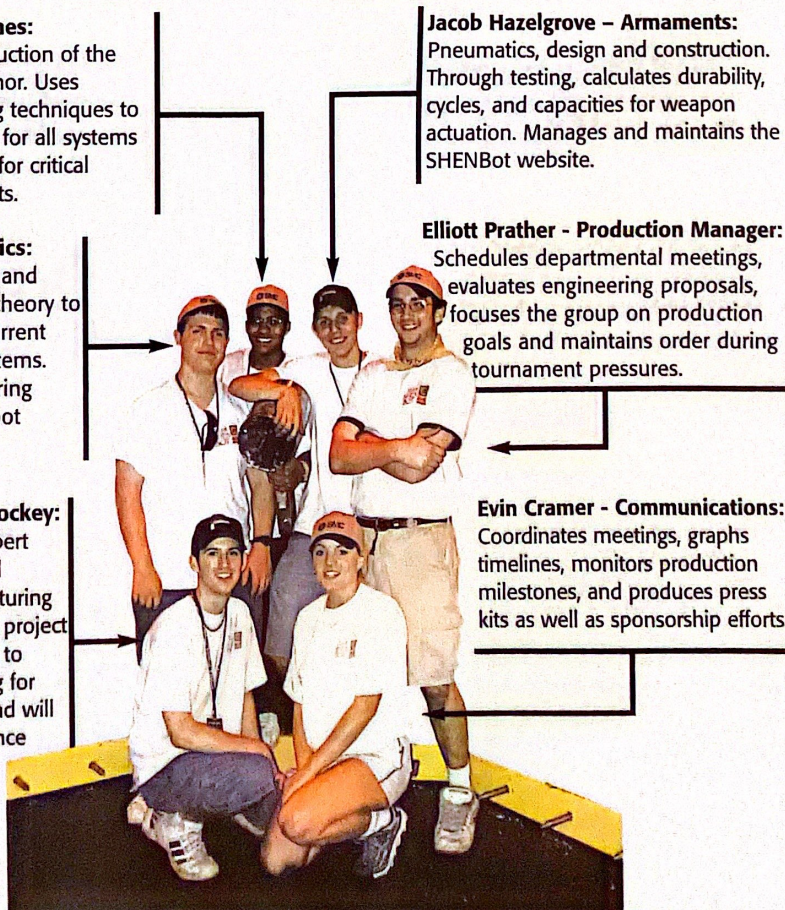
Pneumatics, design and construction. Through testing, calculates durability, cycles, and capacities for weapon actuation. Manages and maintains the SHENBot website.

Elliott Prather - Production Manager:

Schedules departmental meetings, evaluates engineering proposals, focuses the group on production goals and maintains order during tournament pressures.

Evin Cramer - Communications:

Coordinates meetings, graphs timelines, monitors production milestones, and produces press kits as well as sponsorship efforts.



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March 2002

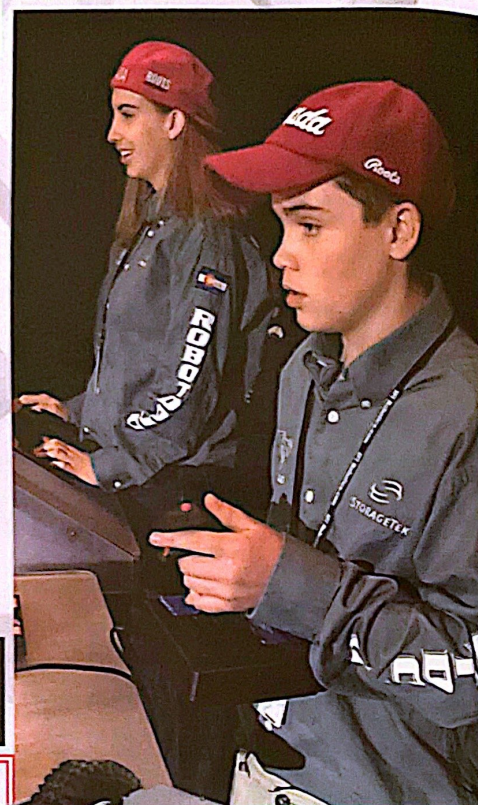
TOURNAMENT CHAMPION - WEE WILLY WEDGIE

Mike Konshak, a master BattleBot builder, uses his weekends to mentor Broomfield, Colorado students in the art of Bot Building. The engineering brilliance of Team Robotdojo and the keen driving ability of Jeff McLay was the winning combination at this inaugural tournament.

As a bonus to being the BBIQ champion, BattleBots sent Wee Willy Wedgie to the Season 5.0 tournament in San Francisco. Tune in this Fall to watch Jeff and Wee Willy Wedgie fight their way to the Giant Nut. To become skilled in the art of robot building and learn more about how Wee Willy Wedgie was built, log on to www.robotdojo.com



Stephanie Zengerle (left) operates the arena hazards as Jeff McLay (right) drives Wee Willy Wedgie to a BBIQ victory.



SECOND PLACE - THE EDGE MOST AGGRESSIVE - THE EDGE

Students from Jesuit High school, in combination with SECR (South Eastern Combat Robotics), formed an outstanding team and a highly competitive robot. Jesuit High is a college preparatory school that has no facilities for the teachings of craftsmanship skills like metallurgy. The determined High School Juniors found the resources they needed in the SECR organization. SECR not only provided a Bot building facility but also taught the students the ways of robot creation. With a time frame of two months and no outside funding, the allure of a BattleBot IQ national high school

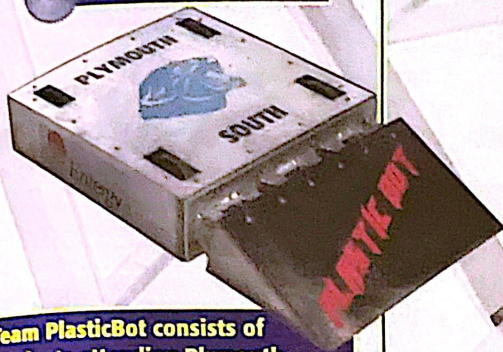
tournament gave Team UI the inspiration to complete and compete. Marc DeVidts practiced for countless hours on the tactics of driving, which in turn won him the Most Aggressive Driver award, and led his team to a victorious second place. The team was able to hammer out the flaws and bring The Edge to BattleBots Season 5.0 for a most excellent run at the Giant Nut. Team UI looks forward to returning in the spring for the next BattleBots IQ.



Driver of The Edge Marc DeVidts (right) and his wingman/hazard operator Chris Williamson (left) explain that the key to being a successful BattleBots IQ competitor is having extraordinary eye/hand coordination, lightning fast reflexes, and opposable thumbs.



THIRD PLACE PLASTICBOT



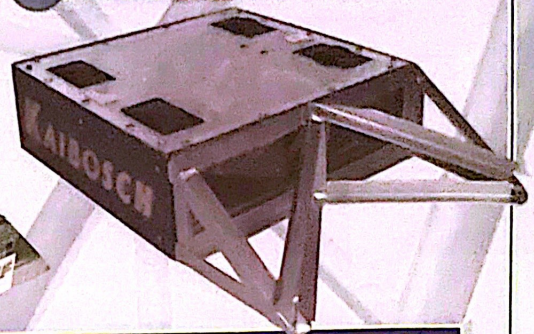
Team PlasticBot consists of students attending Plymouth South High School, Massachusetts.

FOURTH PLACE EVIL EAGLE



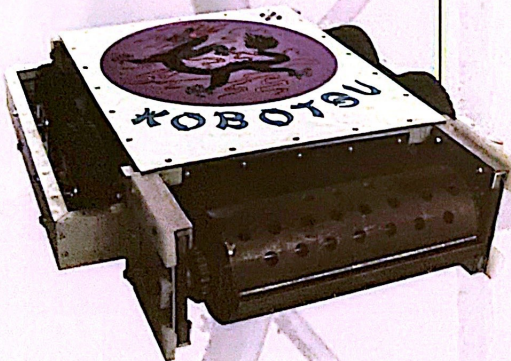
Evil Eagle was created by students attending Hauppauge High School, New York.

RUMBLE CHAMPION KAIBOSCH



A Rumble is a five-minute challenge in which a multitude of BattleBots run at the same time. Conquering a trail of difficult pit repairs, Team Evolution successfully powered their BattleBot Kaibosch through all Rumbles to bring home a win for the Gow School (South Wales, NY).

BEST USE OF AN IFI CONTROLLER KOBOTSU



BEST OPERATORS DEFENESTRATOR



BEST ENGINEERED WHIRLWIND



OUTSTANDING SPORTSMANSHIP

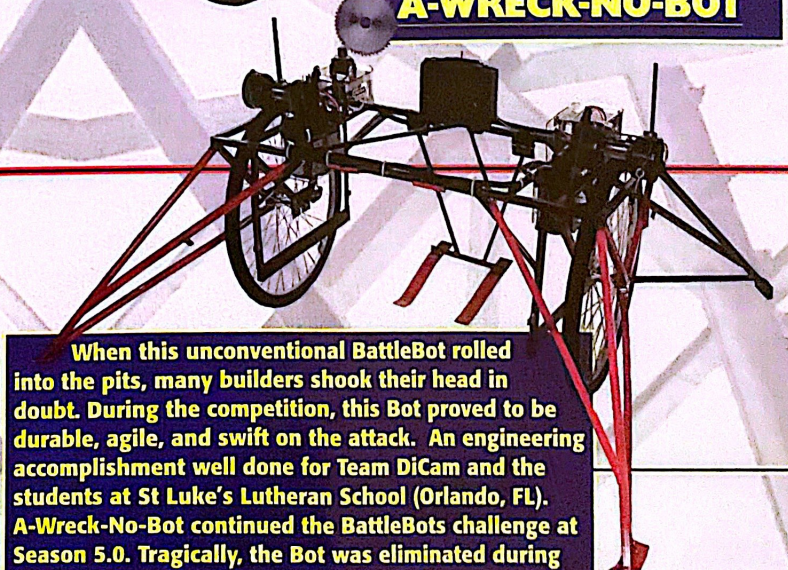
Due to valorized sportsmanship being a common virtue, this category resulted in a five way tie.

ACCELERATOR
HAMMERROYD
METAL FURY
WEE WILLY WEDGIE
HAPPY SCRAPPY HERO

LINCOLN ELECTRIC WINNERS OF WELDERS

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PLYMOUTH NORTH HIGH (PLYMOUTH, MA)
STARBOT FACILITY (MIAMI, FL)
HAUPPAUGE HIGH (HAUPPAUGE, NY)

COOLEST BATTLEBOT A-WRECK-NO-BOT



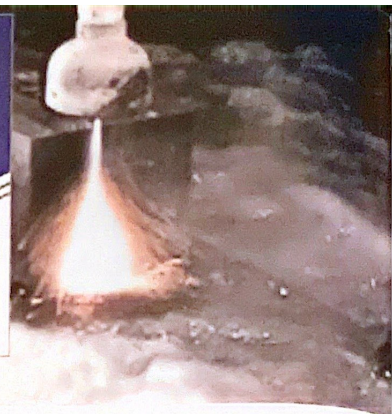
When this unconventional BattleBot rolled into the pits, many builders shook their head in doubt. During the competition, this Bot proved to be durable, agile, and swift on the attack. An engineering accomplishment well done for Team DiCam and the students at St Luke's Lutheran School (Orlando, FL). A-Wreck-No-Bot continued the BattleBots challenge at Season 5.0. Tragically, the Bot was eliminated during Season 5.0 prelims by Wee Willy Wedgie.

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Abrasive Water Jet for Bot Builders

Back in the early 1970's, a former senior research scientist at Boeing founded a company in his basement (does this sound familiar?), which became the Flow Corporation. The first technology commercialized by his company was an ultrahigh-pressure (30,000 to 100,000 psi) water jet used as an industrial cutting tool. Flow later developed the abrasive water jet to cut harder materials.

Abrasive water jet (AWJ) cutting is like supersonic erosion. The water jet is from 0.03" to 0.05" in diameter and flows at 2,250 mph (three times the speed of sound), carrying a solid material, like garnet. It can blast through 8"-thick Titanium with no problem. Dimensional tolerances for parts cut with an AWJ range from 60.002", which is uncommon, to 60.01", which most shops can do. The jet is moved over the material by a computer controlled 2-axis traverse. AWJ technology can cut almost any two dimensional shape out of just about any material.

AWJ cutting offers distinct advantages over other cutting technologies for the BattleBot builder. The finish of an AWJ cut does not require secondary machining like plasma or oxyfuel cutting. AWJ cutting does not produce a heat-affected zone (HAZ) as does plasma, oxyfuel or laser cutting. Parts cut with these other technologies have altered material

properties in the HAZ, which are directly adjacent to the cut edge. AWJ can be used to cut heat-treated materials without affecting the temper. So, you can buy your material with the temper that you need in your final part instead of going to another shop for heat-treating after your part is formed.

If you are proficient at using a CAD program, you can design your bot and e-mail the part drawing files to an AWJ shop. In about a week, you will receive your parts precisely as you drew them and at a reasonable cost.

Here are a few guidelines for designing parts to be cut with an AWJ:

1. Avoid sharp corners or tight radii. Most AWJs will overshoot an inside corner if it is defined as two lines. The same applies to outside corners, but the overshoot is not into your part. Apply a radius (fillet) to all corners.

2. Use small 0.05" diameter circles to locate holes that require secondary machining like drilling and tapping. This will eliminate the markup that you will have to do when you get your part. If it is made of an especially hard material, then you should define holes close to, but smaller, than the drill size required.

3. AWJ cutting will produce a taper of a few thousandths of an inch on the cut edge. This will vary with the thickness of the material. For most chassis/armor parts, this is not an issue.

Following are a few guidelines for drawing and transmitting parts to be cut with an AWJ:

1. Translate (export) your CAD drawings to an ASCII DXF file. The AutoCad R12 DXF file format is universally acceptable. If you can't, then coordinate with the shop with which you are working to use a different format.

2. Keep your DXF files clean. If you have lines on top of lines or end points that do not match, then the file will have to be modified. Either way, unclean files will end up costing you time and money.

3. Be sure to draw your parts to scale (1 to 1). This is good CAD practice anyway. Your resulting DXF files will be at the same scale as your drawings.

4. Inform the shop about any tolerances required for your part. In most cases, you will not need to provide a tolerance at all. Standard tolerances will be acceptable for most chassis/armor parts. Be careful that you don't ask for a tight tolerance when it isn't required, unless you like paying extra.

5. Coordinate material acquisition with the shop with which you are working. The best way to go is to purchase the material and send it to the shop or have it shipped directly to them. If the material is common, the shop may have some, but they usually don't stock much material.

Michael Schwob - Hyperbotics
 Gary Cole - DC Waterjet

Arndt's Art



For many of us, bot building is merely the canvas on which we apply our diabolical brush strokes. Unlike Picasso, however, we must drill, cut, sand, weld, bend, or in some way, alter the properties of the metal we use. How we do this will define the character of our bot and, in some ways, ourselves.

Along with abrasive jet (water jet) machining, CNC machining is fast becoming the status quo for bot building. A few of us bot builders have the capabilities of doing our own CNC work. Most builders must seek out a willing (and hopefully REALLY willing...\$\$!) CNC-capable shop to machine our ideas into reality. This doesn't necessarily mean that the "CNCless" builder can't contribute to a one-of-a-kind CNC design.

CAD-CAM (Computer Assisted Drafting - Computer Assisted Machining) software has exploded

onto computers across the world, and a lot more people have computers than CNC shops. Programs like Mastercam or Surfcam can put unbelievable creative power into the hands of anyone who is computer literate and has some CAD-CAM training. These programs allow you to draw, assemble, and weigh your bot before you ever cut one piece of metal.

One approach to bot design (the one I tend to use) is to design structural integrity first, then try to incorporate an interesting pattern into it. Being a machinist does help in the design

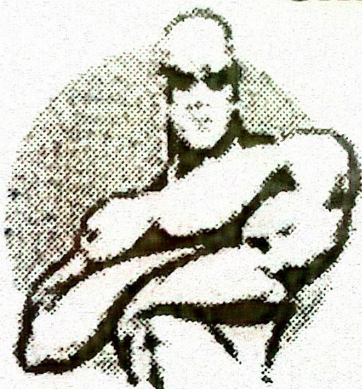
phase, because I'm always looking ahead and asking myself, "How am I actually going to cut this part?" There are as many "tricks of the trade" as there are machinists.

Bottom line: Bot designers/builders are already winners, regardless of the outcome in the arena. People all over the world are able to see our artistic creations, in our lifetime. Michelangelo and da Vinci couldn't even say that!

-Arndt Anderson
Team Sharkbyte

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Joe Szigeti

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Titanium is most famous for its superior strength. Not only is titanium a very strong metal, but it is also lightweight and corrosion- and erosion-resistant. Due to the qualities of titanium, it is largely used in jet engine components. Titanium is famous for its ability to withstand environmental attack...and now thanks to the BattleBot competitor, titanium is also a well-known defense against robot attacks.

Titanium is found as #22 on the periodic chart and naturally occurs in ilmenite and rutile ore. Titanium is commercially produced by reducing titanium tetrachloride with magnesium. Titanium 6AL-4V, or grade 5 titanium, is the

workhorse alloy of the titanium industry, which makes up almost 60% of all titanium consumption. It is used anywhere that a critical strength-to-weight ratio is needed. Grade 5 titanium matches the strength of steel but is just over half the weight, making it the preferred choice for such applications as golf clubs, racing components and, of course, BattleBots. 6AL-4V is the high performance grade of titanium. Using 6% aluminum, 4% vanadium and 90% titanium, it has been tailored to combine brute strength and durability while maintaining its light weight.

Titanium has the ability to naturally produce a very hard oxide film layer. This layer is formed

when titanium comes in contact with oxygen. This enables titanium to prevent damage to the surface and resist corrosion and erosion. If the oxide film is scratched or damaged, as long as oxygen is present, it will regenerate itself. This protective oxide film and its regeneration process give titanium a long-term durability.

While titanium is more expensive than some other metals, it's that durability that pays off in the long run. There are a few tricks in purchasing titanium at lower costs. For instance, while newly milled, certified titanium guarantees its purity and quality, it also has a much higher price. Surplus titanium, on the other hand, offers the same benefits at

a lower cost to the consumer. Aircraft manufacturers are mandated by their industry standards to use certified material. However, for the robot builder, certified material only adds needless cost. Surplus titanium maintains the same properties, but at a fraction of the price.

If you are looking for a high strength, lightweight, extremely durable metal, then titanium 6AL-4V is your answer. Try surplus over certified material to minimize your cost. As the sport of BattleBots evolves, so must the robots, becoming faster, stronger and more durable. Titanium tough? You be the judge!

- Joe Szigeti
Titanium Joe

Dr. Jason Dante Bardis, Ph.D.



WHAT IS A COMPOSITE MATERIAL? SOULD IT BE USE TO BUILD A BATTLEBOT?

You've heard of Kevlar bulletproof vests, fiberglass Corvette fenders, and graphite tennis racquets. A composite material is, well, a composite of two or more materials combined to make a new material that, hopefully, has the best qualities of its components. Many composites are fiber-matrix composites—they are made of a bunch of fibers (carbon, graphite, glass, Kevlar, etc.) suspended in a matrix (usually a polymer like epoxy). The fibers are very strong in tension but weaker in compression. To keep all of the fibers in place and oriented in their desired configurations is the job of the matrix, which isn't particularly strong on its own.

The cool thing about composites is that they are anisotropic (they have different strengths and stiffnesses depending on which way you pull on them), unlike an isotropic material like metal, which has the same properties in all directions. If you're designing a structural component (bot frame, armor, motor mount, whatever) and you have an idea of what sort of loads it's going to experience in battle, you can create a custom composite part that will have its fibers oriented in the optimal direction for the task at hand. The part will be weak if it's loaded otherwise. A metal part is generally heavier than an equivalent composite part intended for the same application, because that metal part is strong in all directions, which can be a waste if your part is never going to be loaded in certain ways. For examples of composite robot parts, go to www.infernolab.com

So, it sounds as if composites are way better than metals—why do most bot builders use metal then? Many reasons:

1-Composites require special equipment and materials to mold, cook ("cure"), and compress into a nice thin part. "Garage builders" and resourceful folks can get by with minimal equipment: an oven, a vacuum cleaner, mold release, and other odds & ends. If you want to make parts as slick and professional as golf clubs, you'll also need a freezer and an autoclave (a combination oven/pressure vessel/vacuum source). It can get pricey. It's very labor-intensive. It's yucky. It involves dealing with nasty chemicals and materials. It makes ordering a chunk of aluminum attractive. Some companies sell pre-cured panels, which saves you lots of hassle, but they are usually flat plates with fibers going in most directions, so you lose control of customizing your layup to tailor it to your application.

2-Composites are generally comprised of several layers of sheets of fibers with the matrix holding them all together. You decide how many sheets to use and how to orient them and laminate them together to get good properties for the finished part. Unfortunately, even though these fibers are strong, the matrix holding them together is pretty weak, and if a crack develops (delamination) between two fiber layers (plies) in a part, there's very little preventing that crack from growing and splitting your part all the way down the middle. There are some methods that the big aerospace companies use to get around this, but there's not much that the average builder can do. Composites are said to have poor "damage tolerance". If they take an impact and break internally, they don't have much strength left. Metals can generally absorb quite a

beating without weakening them as much. While this may be a detrimental to a bot's baseplate, it can be a beneficial property for non-structural armor panels that are designed to absorb energy from spinner weapons.

3-Machining composite parts is nasty. Nasty dust is created, nasty splinters get in your skin, and strong fibers like carbon and graphite are very tough on cutting tools like end mills and band saws. You'll need to get a whole new set of tools (carbide or diamond grit abrasive tools are good) if you want to work with the stuff properly. And expect to deal with splinters for the life of your bot, not just when you're machining it—any combat damage results in jagged splinters that inevitably end up in your fingers...

But, if you're ready to tackle composites, you can create awesome, complex parts that could only be recreated in metal by using CNC machining and fastening several different pieces together. You can have an incredibly light, stiff, and thin structure that is superior to a metal version of the same.

And composites have one more advantage—they look cool.

Dr. Jason Dante Bardis, champion Bot Builder and tournamnet contender. Jason's laudable presence in the pit is heightened by his orchestrated command of the BattleBox. Logon to www.infernolab.com and peruse all of Jason's creations and building techniques. Jason has just finished up his Ph.D. in Mechanical Engineering and is in the market for a fun robot-related job that will let him work on his BattleBots after hours.

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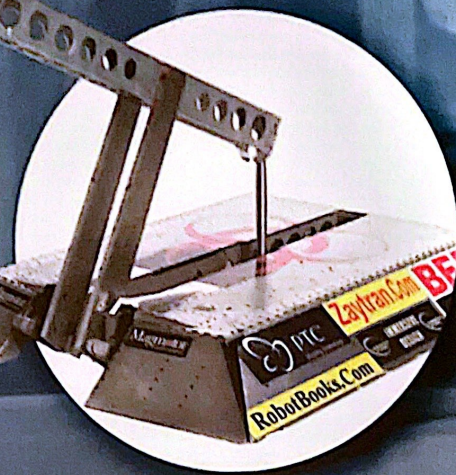
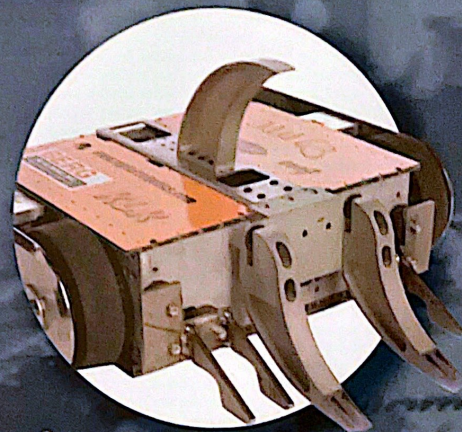
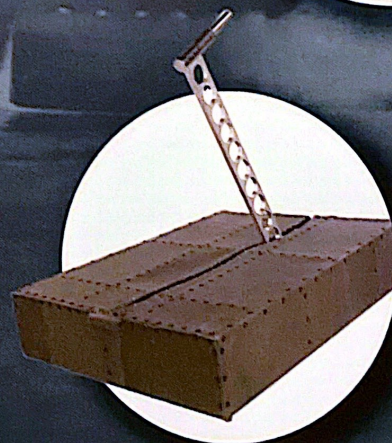
Create Killer Designs...

...then watch them
overwhelm the competition.

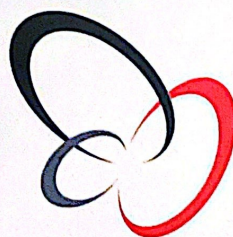
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BATTLEBOTS WARHEAD - 2002



HEAT TREATING FOR THE BUILDER

Here is a test for BattleBots magazine readers.
What is "heat treating?"

- A. Drying hair after a shower
- B. Cooking food in an oven
- C. A sauna session at Sonoma Mission Inn & Spa
- D. Thawing a frozen pipe with a propane torch in January
- E. A banned BattleBots weapon technique
- F. An operation or combination of operations involving the heating and cooling of a metal or alloy in the solid state for the purpose of obtaining certain desirable conditions or properties
- G. All of the above

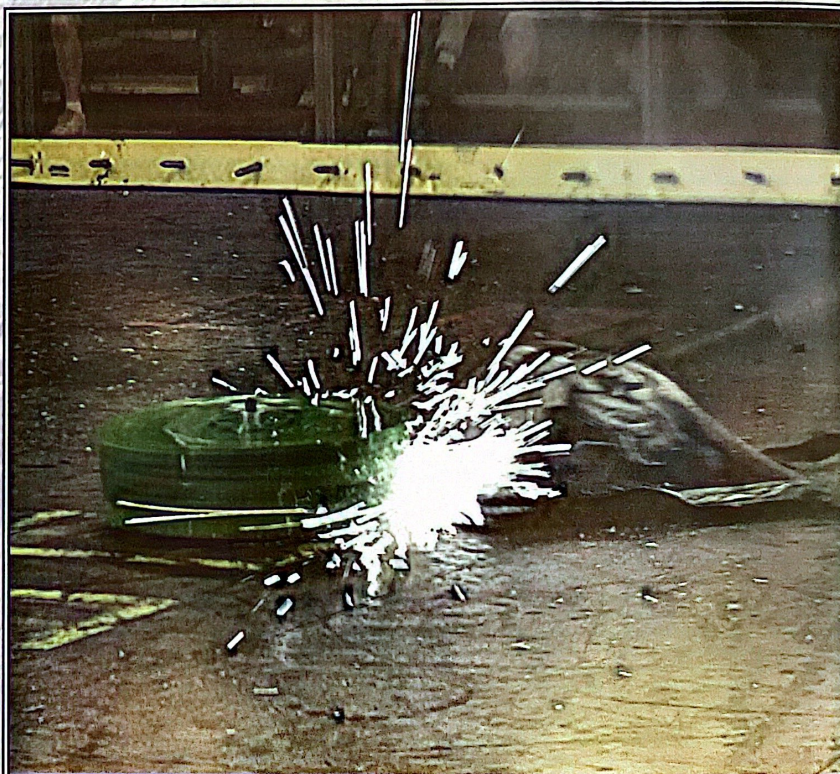
Many fans of robotic competition will instantly point out that the correct answer is **H**. These overachievers demonstrate that BattleBots fans tend to be "ahead of the power curve," intellectual and capable of "thinking outside The Box," so to speak. It is to this audience that the following overview of metal heat treating as it relates to robot construction materials is dedicated. To BattleBot Builders out there who poo-poo this type of discussion and want to flip the page to the cool photos, please understand that your Bot may be taken out of the next competition by some 15 year old kid who learned how to make his parts twice as tough as your parts.

Many fighting robots use impressive offensive weapons designed to damage opponents, put them at some tactical disadvantage and gain points. On defense, Bots need to resist weapons and arena hazards yet maintain some offensive capability. One type of design may tend to do well against another, yet be victim to a third. In this inherent Rock-Paper-Scissors game of robotic competition design, we can also witness a similar dynamic occurring metallurgically. Some metals are able to defeat others, all else being equal. We will take a brief look at some common materials, particularly steels, and how

special thermal treatments can enhance their properties. This is a huge subject full of chemistry and physics, so we will just scratch and sniff a bit.

Metal is the material of choice when it comes to building a BattleBot. Why you ask, when useful products like nylon, wood, glass, paper, styrofoam, leather and duct tape are so widely available and cheap? Here's the deal: all materials have both positive and negative features and are chosen for a given application because their good points outweigh the bad. Metal offers more resistance to abrasion than leather, but metal is never used to build a motorcycle road-racing suit. It is not flexible enough. Leather has just the right combination of toughness, flexibility, ease of manufacture, price and appearance. Within the world of fighting robots, metal talks and leather walks. Even within the category of metal, we find that there are many different types to choose from.

Fighting robots are generally constructed from steel, aluminum and titanium (not to mention plastics and composites just to flesh out a nice Darwinian mix...). Each one of these categories offers a variety of choices. Designers don't choose titanium just because it makes bright, white sparks when sawed by an opponent, no matter how much the spectators love it. They spend big bucks on titanium because it has an excellent strength-to-weight ratio right off the shelf and because the sponsor is paying for it. I mean it gets them into the next lighter weight category. That's the ticket - weight category. Anyway, all metals offer varying degrees of performance in the areas of hardness, toughness, ductility, resistance to abrasion, weldability, machinability, strength-to-weight ratio, corrosion resistance, availability, magnetic or electrical properties and cost.



Soon after Moebius's (left) first bout, this BattleBot was tagged as one of the most feared contenders at Season 5.0. Like most of Moebius's opponents, El Spooky (right) was opened up like a can of beans. Once El Spook's armor had been sufficiently compromised, Team Ghetto Logic Robotics tapped out in efforts of saving their internal components.

John Neuenburg performs marketing services for several industrial manufacturing job shops in the San Francisco Bay Area. Additional information about metal working and metal finishing may be found at his web site, www.IndustrialJobShops.com

Unless one is in the metalworking business, most people do not know much about steels and how they can be optimized. There are many types available and each fills a performance niche. The basic categories are carbon, alloy, tool, stainless and special purpose steels. Steel is iron with the addition of carbon up to a maximum of 2%. Most steels have less than 1% carbon, and if the grade contains minimal amounts of other elements it is called "carbon steel." A common grade of carbon steel is 1018, which is a simple mix of iron and carbon (the 1000 series) with the last two numbers signifying the fraction of one percent carbon content. This 0.18% carbon steel is very weldable, machineable, inexpensive and available in a wide variety of shapes. It rusts and is magnetic. Unfortunately, it is not too strong for structural or weapon purposes. Other elements can be added to steels by the mills to drastically improve their strength potential. This is where fans of robotic competition should start to get interested.

As steel exceeds 0.30% carbon, an interesting thing occurs: it can be hardened by the application of heat followed by a rapid cooling step. Simply, this is because the iron, carbon and anything else in there turns into a solid solution called austenite at about 1600 ° F. Atoms become fairly evenly distributed. If left to cool slowly, atoms and molecules will revert back to whatever crystalline form they were in at the beginning. Annealing and normalizing are heat treatments similar to this and we will not go into these here. However if the cooling is accelerated, such as with a water or oil quench, a different type of crystalline structure is developed and locked in as the metal approaches room temperature. This structure, called martensite, is very hard and unstable (brittle). Normally a second, lower temperature heating cycle is then applied which takes this brittleness away and increases ductility, which is the resistance to breakage when the part is deflected. This second heating step is called tempering, or drawing. Through-hardening is the meat and potatoes of industrial heat treating job shops who will work with your machinist or metal fabricator to provide the optimum part for the job.

The most common measurement of hardness in steels is via the Rockwell C scale. Rc20 is not very hard and Rc65 is extremely hard. Hardness relates directly to abrasion resistance and the ability of the part to deflect and return to its original shape without becoming "tweaked." Think of a spring. Hard can also be brittle, which is the trade-off when selecting materials. (Deep cryogenic processing can be a big upgrade to a conventional hardening job from the standpoint of resisting abrasion and cracking but that is beyond the scope of our discussion here.)

(continued page 24)



The undefeated middleweight champion Hazard uses a hardened tool steel horizontal spinning blade that registers a hearty 50 on the Rockwell Scale.

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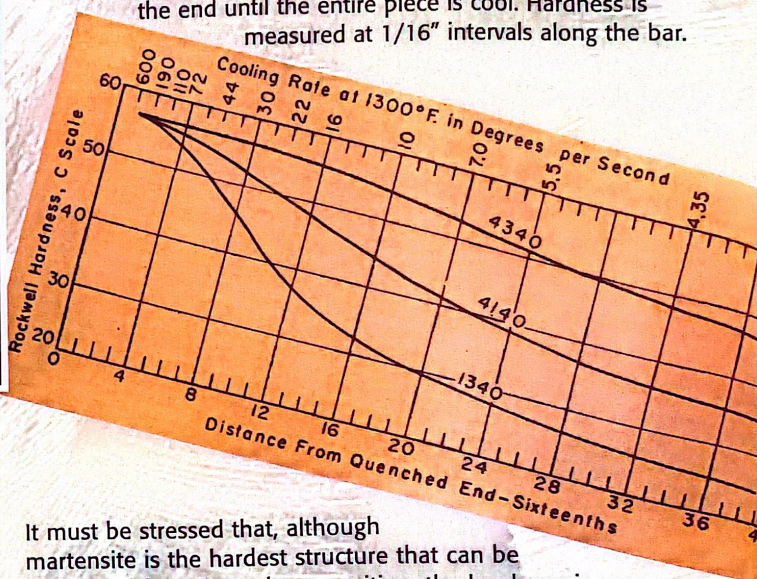
(continued from page 23)

As carbon goes up, maximum hardness does too. Carbon content over 0.70% makes what is considered spring or tool steel. Unfortunately, high carbon decreases weldability and machinability, even when the steel is in its softest state. One problem that carbon steel exhibits is a resistance to hardening when in thick sections. It needs to be quenched very fast, which is impossible in a part that retains a lot of heat. For these purposes, and to achieve higher ultimate hardness, we use alloy steels. Steel mills add chromium, nickel, molybdenum, silicon, manganese, tungsten and vanadium to achieve excellent hardenability, toughness, ability to work when hot and other properties. 4130 is a chromium-molybdenum alloy that can achieve decent hardness yet is very weldable. This can be good for a tubular chassis but one has to watch out for excessive stress and hardness in the areas affected by welding heat. A stress-relieving thermal process can help this. 4140 and 4340 are upgrades in the hardenability area and are



recommended for axles and shafts. Tool steels are the most hardenable and have other interesting properties. They can be brittle, hard to machine and difficult to weld. Nevertheless, these are the grades to use for many of the typical robot weapons because of their ability to beat up most of the more commonly used robot materials. S-7 is a shock-resisting tool steel very common in robots. It may get to only Rc50, but it is very good at combating catastrophic failure. A2 is an air hardening tool steel that will achieve good hardness without the necessity of the liquid quench that almost always causes distortion. This saves a straightening step or extra grinding. M or T series tool steels are used in metal cutting tools and for other extremely hard parts. Although these can be quite brittle, some heat treaters use "secret treatments" to get much better durability at only a small sacrifice in hardness. Stainless steels resist corrosion and some are hardenable, while some are not.

These "Jominy Curves" show the difference in hardenability between a medium carbon steel (1340), a chromium-molybdenum steel (4140) and a chromium-molybdenum-nickel steel (4340). A one inch test bar four inches long is properly heated and quenched just on the end until the entire piece is cool. Hardness is measured at 1/16" intervals along the bar.



It must be stressed that, although martensite is the hardest structure that can be developed for any steel composition, the hardness is dependent on the carbon content. A fully hardened steel with 0.3% carbon will not be as hard as a fully hardened 0.8% carbon steel, even though both structures are 100% martensite.

One category of hardening that could be used to a greater extent in building robots is case hardening, chiefly carburizing. In this process, low carbon alloy steel, such as 8620 or 9310, is machined close to finished dimension, then put into a furnace with a carbon-rich atmosphere. Over time, carbon dissolves into the surface of the steel up to a saturation point based on temperature. A "skin" or "case" of high carbon develops which can be quenched and tempered to achieve very high hardness. Although a case up to .25" can be obtained (after days!), normally a case of .080" would be considered "heavy" and .020" is "light." Areas that are not supposed to be hardened can be copper plated or painted with a heat resistant pair so as to not receive the carbon. These steels exceed Rc60 for wear

resistance yet remain a tough and ductile Rc35 or so through the center of the part. Gears, camshafts and other high wear parts that also receive shock are often carburized. The mild steel 1018 can be carburized to a light case, which can be useful if welding, forming and surface

Darin Ewert, Team Whyachi, patiently waits in the blue square for the signal to start up The Red Square. The robot Red Square is equipped with a treated sheet of spring-steel. This spring-steel acts as a kinetic weapon, which once winched down and released strikes and flicks opposing BattleBots.

hardening is required in the same part. Mild steel sheet and plate can be carburized to better resist robotic sawing, grinding and punching weapons. However, care must be taken to fixture some designs to avoid excessive distortion during the quench.

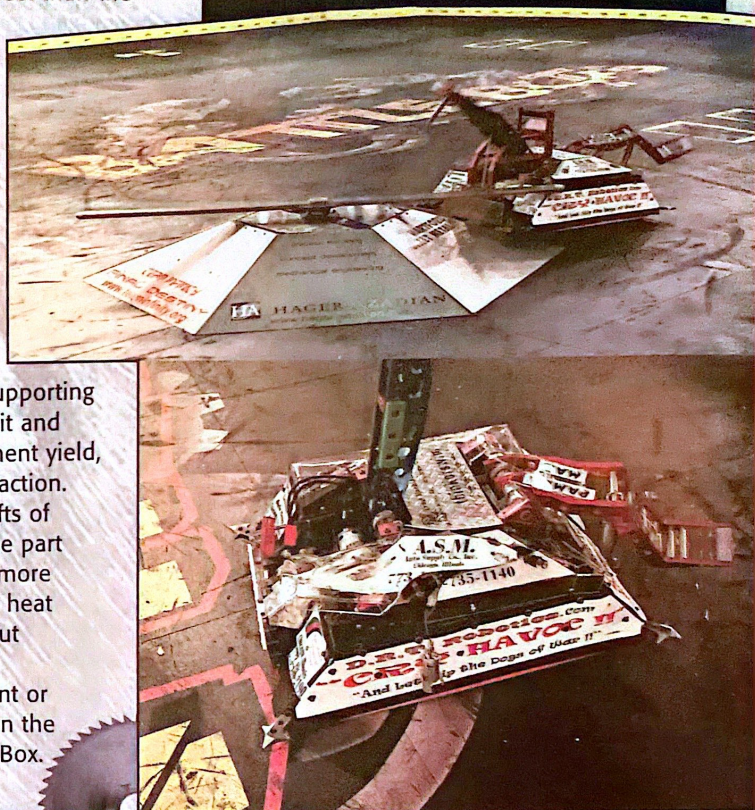
Lastly, consider induction heating for selective hardening or softening of parts. Electric rapid-heating elements allow the heat treater to treat only the wear areas of parts, such as gear teeth or bearing areas of alloy shafts. It may not be advisable to harden the entire part, because shafts can distort or gear centers may not be ductile enough. A useful trick is the annealing (softening) of a previously hardened section for follow-on machining.

Use your heat treater to help you choose robot materials or solve problems. Many parts are designed badly for heat treating and cannot hold up under the stress of quenching. Slight re-designs are often the answer. Watch out for hardening mill finish surfaces! These surfaces are full of imperfections and decarburization that can cause problems. A certain amount of stock removal is recommended for all surfaces that will be subjected to the heating/cooling cycle.

The take-home message here is that, if a part can be made light yet strong, extra

weight can be put elsewhere in the robot. This can mean larger batteries, more armor, larger weapons, etc., while remaining in the desired weight class. Certainly, optimizing the size of the parts is important. Having the upper body panel Blanchard ground to .210" +/- .005" may be more perfect than the .250" you got from the metal warehouse. That five pounds can make a difference. Same goes for optimizing the metallurgy of the parts. Light can be strong. For example, a large, spinning blade can be an excellent weapon. However, it subjects its axle and mounting areas to a lot of stress when it receives a hit. If the parts supporting the weapon can take that hit and spring back without permanent yield, the weapon may still be in action. Ditto axles, wheels and shafts of hopped-up motors. Sure, the part costs more if made from a more expensive material, and the heat treater gets his share too, but compare that with regular replacement of cheaper, bent or broken parts, not to mention the early knockout in the BattleBox.

Cry Havoc's red anodized aluminum frame was light and swift on the attack. Unfortunately, the aluminum structure was no match for the hardened horizontal spinning bar of Final Destiny. The BattleBot Final Destiny relentlessly beat all preliminary challengers on its way to the Giant Nut.



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INTRODUCTION TO POWER TRANSMISSION

This is a brief introduction to the four most common technologies used to transmit power from one rotating shaft to another. There are many less common and proprietary power transmission (PT) systems, but most are variations of these primary four. These sometimes neglected systems are a critical component of every BattleBot. Understanding them may make the difference in winning or losing your next bout.

Roller Chain

The most common roller chains used in BattleBot PT systems are ANSI standard #25 and #35. These are 1/4" and 3/8" pitch respectively. The larger the pitch, the lower the maximum linear chain speed and the greater the torque capacity, weight and space requirements. Other chain designs are available (such as bicycle chain), but the corresponding sprocket selection may be limited. It is best to use ANSI standard chain, as there is a virtually unlimited supply of parts.

Roller chain allows great flexibility in design. It can be used to drive multiple shafts and can be arranged in a serpentine fashion. Roller chain can also be broken with an inexpensive tool to make any length, which is a multiple of the pitch. Unsprung tensioners should be used to take up slack if required.

Roller chain is very forgiving relative to most other PT technology. Even when installed improperly in a poorly designed system it will work with some degree of reliability.

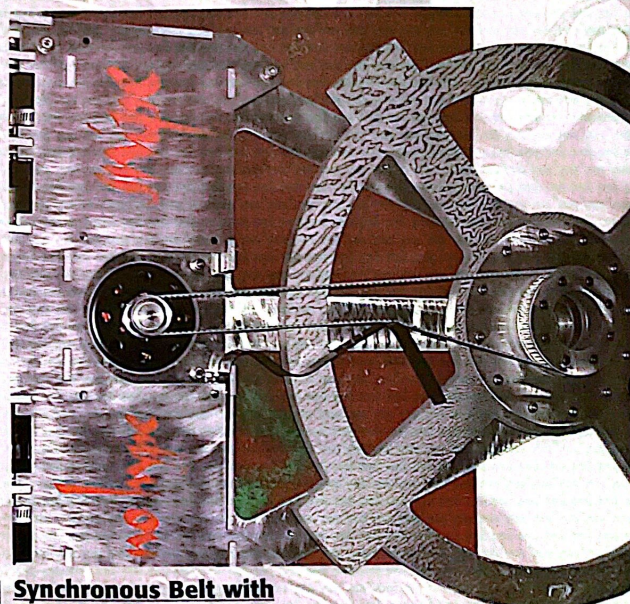
Roller chain is typically made of steel alloy and requires frequent initial tension adjustment due to stretching. Roller chain sprockets are most commonly made of mild steel but are available in stainless steel, aluminum and most high strength plastics such as nylon.

Synchronous Belt

Also referred to as timing belt. Classical timing belts have a trapezoidal tooth profile and as their name implies were originally intended to synchronize two shafts. High torque (HTD) synchronous belts have a curvilinear tooth profile to maximize transmission capacity and efficiency. The HTD belt was developed to replace chain. This type of synchronous belt and its many variations are the most common belts used in BattleBot PT systems.

HTD synchronous belts and sprockets are available in pitches from 3mm to 14mm. Various standard lengths and widths are obtainable for each pitch size. Greater widths carry more power. Endless and open-ended belts are available. Synchronous belts most typically have teeth on one side, but double-sided belts do exist.

High performance synchronous belts are usually constructed of polyurethane reinforced with high tensile cords such as glass fibers, which have a high resistance to elongation. As a result, synchronous belt drives do not require frequent initial tensioning adjustment. Synchronous belt sprockets are available in steel and aluminum as well as many high strength plastics.

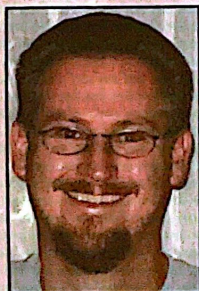
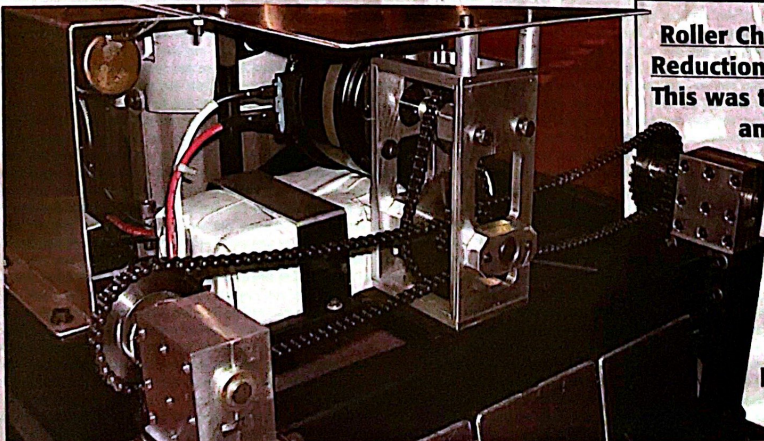


Synchronous Belt with Homemade Spring Tensioner

Team Scrounge Lizard's creation Happy Scrappy Hero Pup was yet another BBIQ robot to make a run at the World Championship Nut. Happy Scrappy Hero was able to rebuild in time for the BattleBots 5.0 Tournament only to be cut down in the preliminary bouts by its arch nemesis, BBIQ Runner-Up, The Edge.

Roller Chain System with Two Stages of Speed Reduction and Single Motor Driving Two Wheels

This was the first tournament for both Dan Bonvinich and his BattleBot Rest In Pieces (RIP). Newly built and untested RIP was matched up against The Brick, RIP's first and last opponent of season 5.0. The Brick pummeled the chromoly steel frame of RIP, buckling the mounts that held the S7 tool steel spinning blade in place. Crumbled to defeat, Dan tapped out, but not without leaving a few battle scars on The Brick.

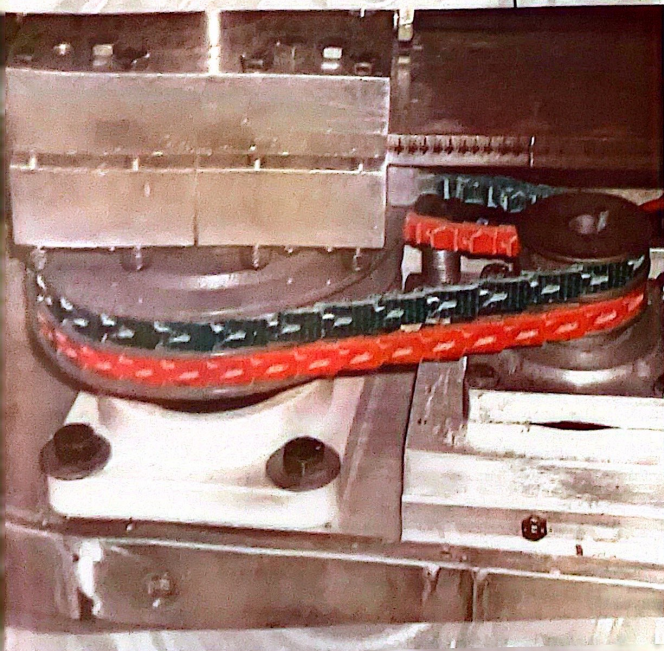


V-Belt

Unlike the other three PT technologies presented, v-belt drives are friction drives. As their name implies, v-belts are shaped like a "v" or wedge. The belt engages the pulley (sheave) on the sides. This wedging action increases the friction force by a factor of at least 3.25. Since there is no positive engagement as with the other three PT technologies v-belt drives do exhibit a certain amount of slip, which results in a 1% to 2% reduction in efficiency.



A useful characteristic of v-belt drives is that they isolate drive mechanisms from vibration and shock. For this reason, v-belts are the most common PT system used for spinning weapon drives. In this application, the reaction torque resulting from an impact is attenuated by a clutching action. The belt will slip on the small sheave which is usually on the motor. This also makes the v-belt drive more likely to survive the impact than a positive engagement PT system.



V-belts and matching sheaves are available in many standard and commonly available sizes and designs. The two most common v-belt cross-section designs are the classical (sizes A through E) and the narrow (sizes 3V, 5V and 8V). Narrow belts can transmit up to three times more power than a classical belt of the same size. V-belts are also available with top ribs as well as molded notches (cogged). Both of these variations increase the capacity of the belt to transmit power.

Link v-belts are constructed of interlocking links. They give the builder certain flexibility over standard v-belts. It is a simple task to change the length of the belt or fix a broken belt and a bucket of links can take the place of

Two Cogged V-Belts

Spinning the Weapon Drive Nightmare, a BattleBot that needs no introduction, uses a 48volt Briggs & Stratton ETEK to spin up its 42" diameter 6061aluminium Vertical Spinning Disk. Be sure not to miss Nightmare doing battle on Comedy Central this fall.

shelves of fixed length belts. They are reported to have the same power rating as standard v-belts of same size and offer more shock and vibration isolation. V-belts are constructed similar to synchronous belts with high tensile cords, such as polyester, encased in a flexible material. Neoprene and synthetic rubber are common materials for the casing. As such, they stretch little and require infrequent initial tension adjustment.

Two Linked V-Belts

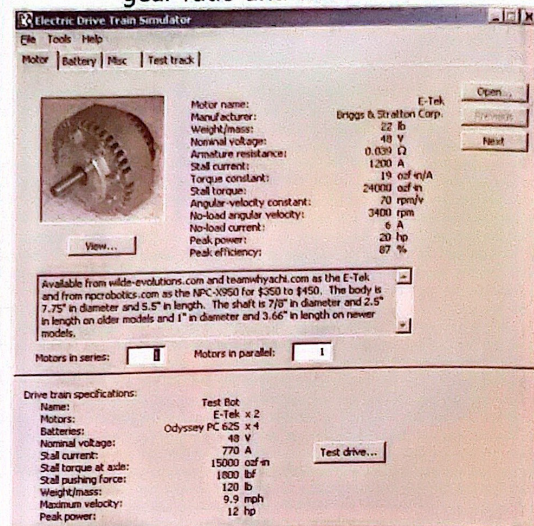
Mr. Bonestripper, a BattleBot by Team Wetware, uses a 4" Magmotor to spin up its 64" long titanium blade with tool steel hitter heads. Ray Scully, team Wetware's commander, has a fleet of four BattleBots that he has been fighting since 1999. Three years later, and several thousand valuable lessons learned, Ray wins his first bout at the Season 5.0 preliminaries. According to Ray, "This is a sign of changing times, the curse of Team Wetware has been lifted and a bright future is in store."

EDTSim

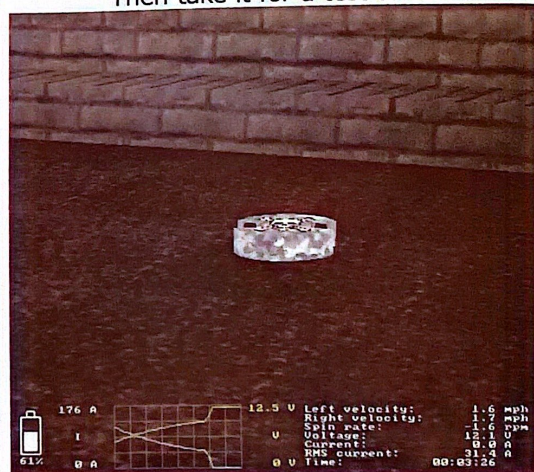
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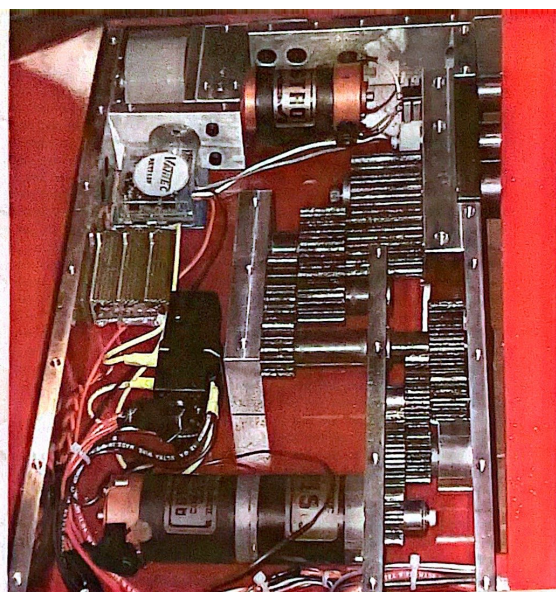
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Gears

Gears come in many forms, which can be generally classified as parallel shaft, intersecting shaft (bevel) and non-intersecting/non-parallel shaft. The first category is the most common and includes spur gears. The most prevalent gear in the third category is the worm gear. Standard worm gear drives are 90% efficient at best should and only be used as a last resort. If the application requires non-intersecting/non-parallel shafts, then a double enveloping worm or hypoid gear set should be used.

Gears are available which are made of many different metals and plastics and come in a variety of geometries as indicated above. Designing a gearbox from scratch requires a great deal of engineering and highly accurate machining. Stock gears can be used for simple gear trains, but this still requires a high degree of mechanical design skill and accurate machining. If a gear drive fits the application best, then a complete pre-engineered gearbox should be used. These, however, will typically cost much more than the other power transmission technologies.



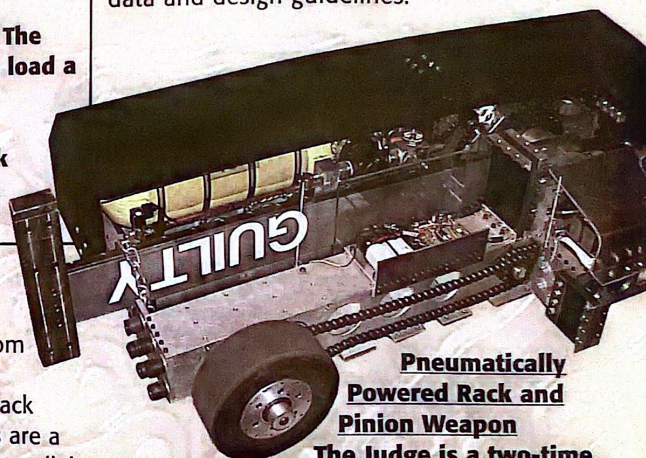
Custom Spur Gear Power Train with Multiple Stages of Speed Reduction and Torque Amplification
Team Whyachi's newest addition to their BattleBot squadron is this creation called **The Red Square**. The gears shown are used to load a large leaf spring that launches opponents across the BattleBox like a medieval catapult. The Red Square was able to flick its way through the preliminaries, leaving a string of defeated robots in its wake.

Rack and Pinion

Although rack and pinion systems technically do not transmit power from one shaft to another they deserve a special mention. Rack and pinion systems are a special case of the parallel shaft type gear. The rack is essentially a gear with

an infinite radius. Rack and pinion drives belong to a special class of PT systems, which convert rotary motion to linear motion. Acme and ball-bearing power screws, which are commonly used in linear actuators, also belong to this class. These types of PT systems are limited to use in weapons with restricted motion.

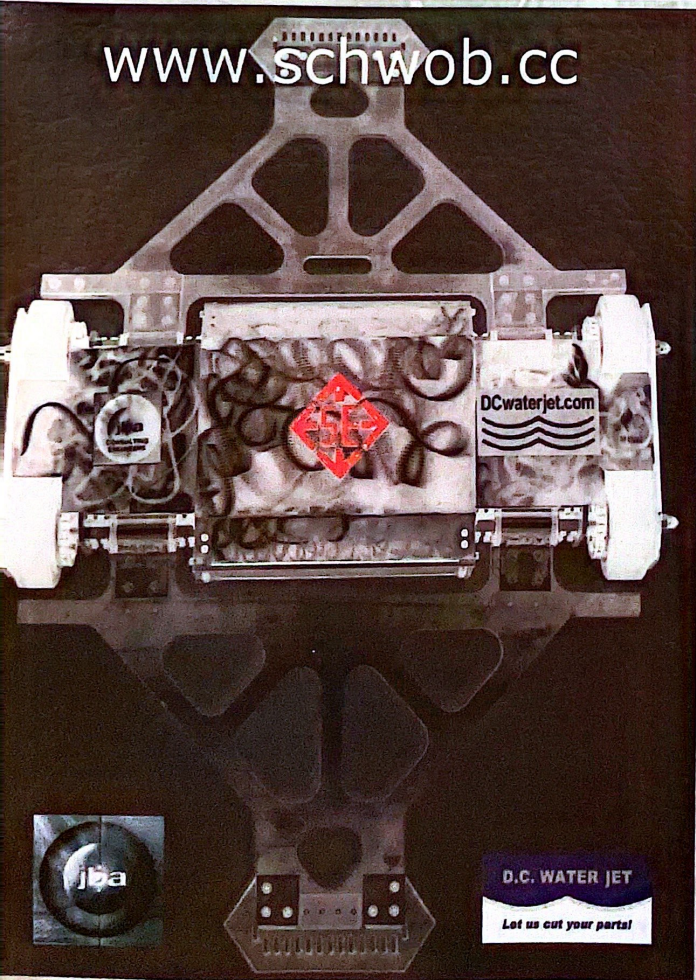
It is not possible to say that one type of PT technology is superior to all others. Each application requires a careful consideration of relevant factors. These factors vary for every application and not only by type of application. No matter what type of PT technology you select the most important thing you can do to make a successful bot is to use proper design and installation practices. PT component selection and application should always be based on published manufacturer's data and design guidelines.



Pneumatically Powered Rack and Pinion Weapon

The Judge is a two-time winner of the BattleBots "Best Engineering" Award. This honor is due mostly to its ingenious rack and pinion gavel.

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The following table presents typical quantitative values for various power transmission system characteristics. These values are based on the best available information and are intended to illustrate the similarities and differences between the four primary power transmission system types. These numbers do not include exceptions to the norm. When designing a power transmission system, the manufacturers published data should be used.

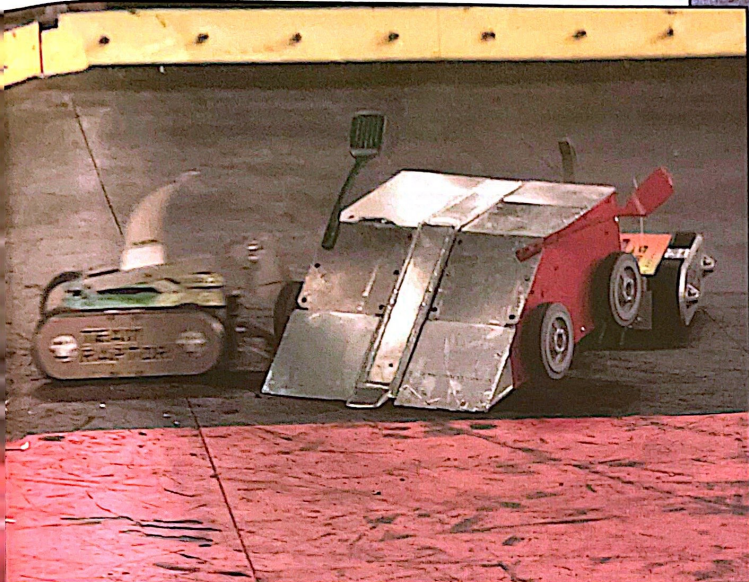
	Roller Chain	Synch. Belt	V-Belt	Gear [1]
Max. Efficiency (%) [2]	94 - 98	93 - 98	92 - 95	97 - 99.5
Lubrication Required	Yes	No	No	Yes
Max. Linear Speed (ft./min.) [3]	3,000	6,500 [7]	6,000 [7]	4,000 [5]
Max. Speed Ratio [4]	1:7	1:10	1:10	1:5 [6]

Notes:

1. Includes spur, helical, double helical and conformal parallel shaft gears (parallel shaft).
2. Under ideal conditions.
3. Recommended for best operation.
4. Practical limit for a single stage.
5. At the pitch radius.
6. For spur gears. A theoretical ratio of 1:20 can be obtained with double helical.
7. Typically limited by the sprocket or pulley.

TEAM RAPTORS

The Raptor posse have finally mastered the art of the Cluster Bot configuration with the BattleBot entry of The Pack Raptors. The strategic movements of Team Raptor unfolded like war game poetry. Flanking, charging, reposting with aggressive retreats, the combined Pack Raptors would collect valuable points with the judges. All preliminary contenders were shamed in defeat with the lead Pack Raptor and its wingman. Before each bout, the Pack Raptors would raise their weapons as a ceremonious salute to the worthy competitor.



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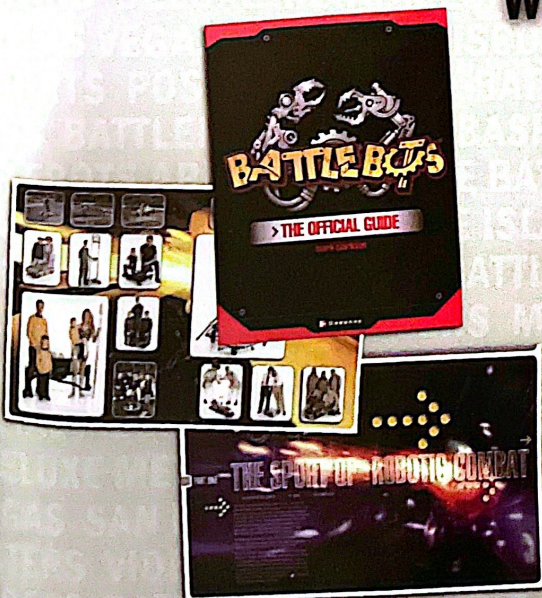


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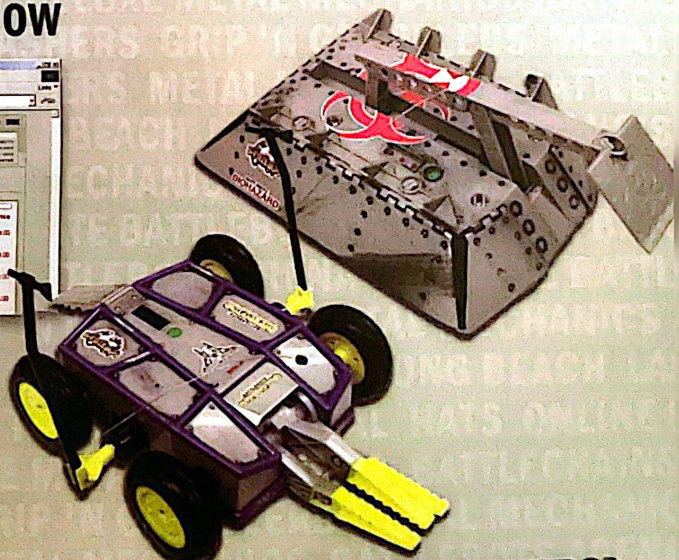
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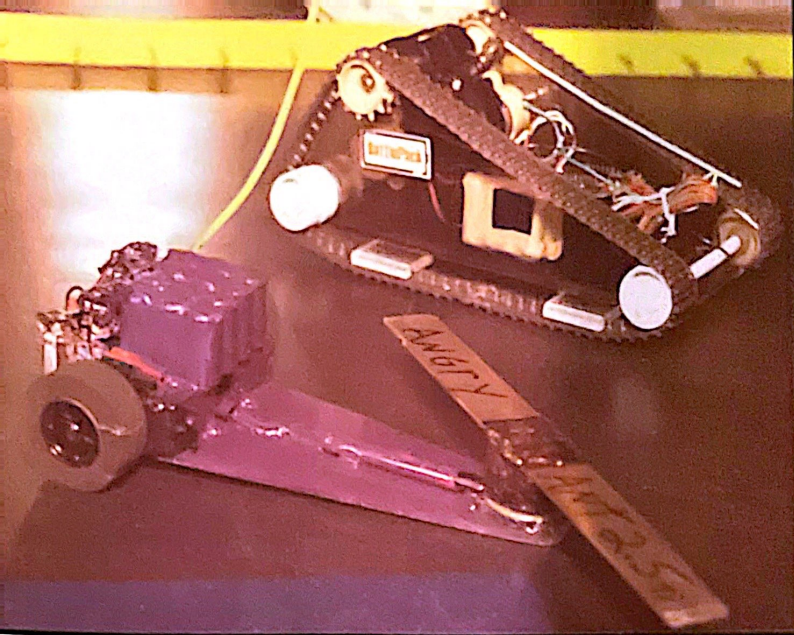
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Summer 2002
BattleBots Magazine 29



BattleBots / SECR presents BATTLEANTS!

It all started on a Friday afternoon, during the break of BattleBots 5.0. Sixteen BattleAnts were hand-picked to appear in this exhibition. The fights were run in standard BattleBots fashion. Many battles came down to a judge decision, yet many more were complete knockouts.

Three Rounds of BattleAnt action dwindeled the collection to the

last two standing Ants. Oishi, the tank, and Hoser'd, the walking spinner of death. Hoser'd spun up its horizontal titanium blade and knocked out a side of Oishi's drive train, and so ended the first BattleAnts Exhibition. The builders had a great time, the crowd enjoyed themselves, and the antweights have made their mark in the robot community. Let's see them live on! To see all the BattleAnts log on to www.secr.org/battleants

Chris Williamson, Marc DeVids
South Eastern Combat Robots
UI Productions



Fuzzy Mauldin's entry TadPole (left) was knocked out of its pond by Peter Abrahamson's Tsunami (right). Judge Dave Calkins (red jacket) officiates the tournament with BattleBots poise.

Rob Purdy

Tim Cristy's Gefahr (right) called an exterminator to Patrick Campbell's micro frenZy (left).



Rob Purdy

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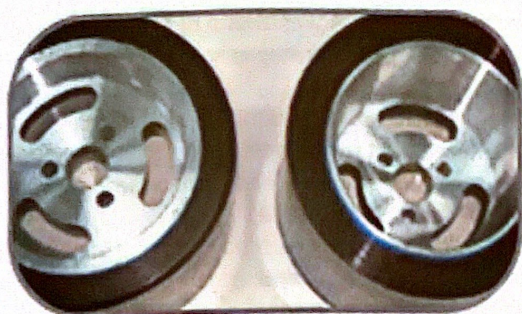
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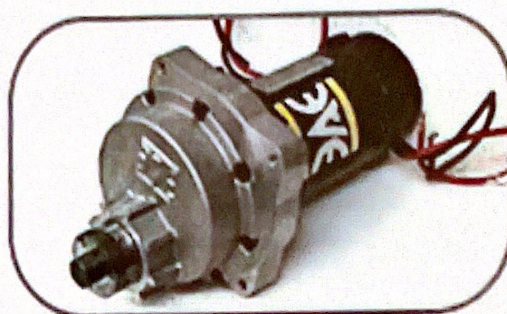
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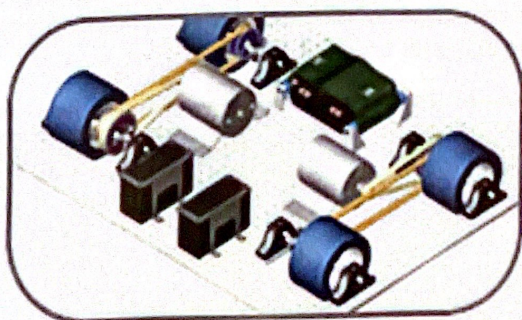
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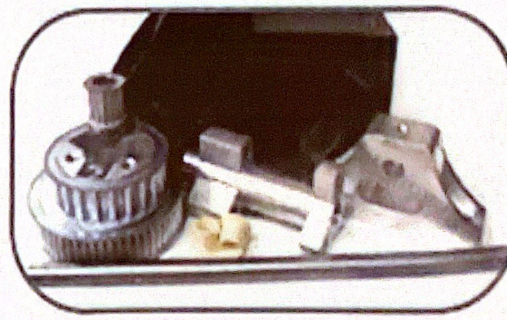
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Dr. Joanne Pransky



32 BattleBots Magazine

FROM THE JUDGE'S BENCH

Sparks flying, robots dying, annihilation and Bot devastation – that's what the sport of BattleBots is all about. However, a knockout doesn't always occur on the BattleBox floor. That is when, as Announcer Mark Beiro puts it, "the three human judges at arena side" have to turn in a vote for the Bot who scores the most points, in accordance with the guidelines in the BattleBots Tournament Rules and Procedures (TR&P).

A judge's role is that of an impartial rules interpreter interested in the administration of Bot Justice. Three judges each award 15 points, for a total of 45 points. For each judge's 15 points, five points in three categories are split between the two opposing BattleBots with the majority of points awarded to the Bot that: 1) shows more aggression, 2) causes more damage to the other BattleBot, and 3) employs and executes a better strategy.

The TR&P further expound on Aggression, Damage, and Strategy:

1. Aggression of a BattleBot is judged based on the frequency, severity, boldness, and effectiveness of attacks deliberately initiated by the BattleBot against any opponent. Control is a factor in Aggression; if a BattleBot is judged to have accidentally attacked an opponent, that act will not be considered Aggression. In contests involving spinners that allow no approach without entering the weapon envelope, more Aggression points will be awarded to the other (non-spinner) BattleBot if it continually attacks and initiates contact with the spinner robot.

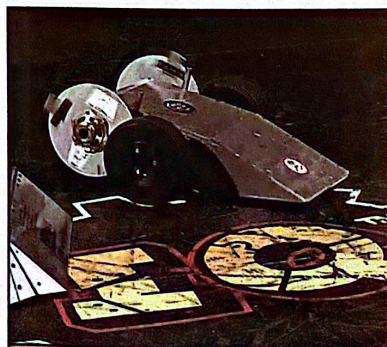
Dr. Joanne Pransky has judged six world championships, beginning with Las Vegas 99. When she's not honing up on the Rules and Regs, Dr. Joanne, a.k.a. The World's First Robotic Psychiatrist (www.robot.md), can be found working with industrial, humanoid, and service robots.

2. Damage means that a BattleBot either directly, or indirectly using the Arena hazards, reduces the functionality, effectiveness or defensibility of an opponent. It will not be considered Damage if an opponent BattleBot inadvertently harms itself. Implicit Damage, where the functionality or effectiveness of the BattleBot is reduced, will be weighed higher than visible external damage. Damage points are only awarded if one BattleBot directly damages, or takes deliberate action that causes the opponent to be damaged. Self-damage on BattleBox hazards, or due to component failure, will not result in awarding points to the opponent.

3. Strategy is defined as a BattleBot exhibiting a controlled attack plan that exploits the BattleBot's strengths against the weaknesses of its opponent. Strategy is also defined as a BattleBot exhibiting a defense plan that guards its weaknesses against the strengths of the opponent. Strategy can also involve using the Arena hazards to gain a relative advantage. A BattleBot that continually avoids contact with its opponent will not gain any Strategy Points for those actions.

Though there's a total of 45 points, every point matters in a split decision. Say Judges A and B score the same, both giving the win to the Bot in the red square (Red Bot) with a total of 16/14

"Although a judge's job is to be a rules expert with authorized opinions and without bias, ... there are undoubtedly plenty of ambiguous situations and controversial calls."



of 8/7 each (3/2 on Aggression, 3/2 on Damage, and 2/3 on Strategy); but Judge C scores a 9/6 for the Bot in the blue square (Blue Bot) with a 2/3 for Aggression, 3/2 for Damage, and 4/1 for Strategy, thereby swaying the final decision to 23/22 for the Blue Bot. Thus, one judge's 3-point spread on Strategy for the Blue Bot outscored the other two judges' votes for the Red Bot.

Judges' decisions are based on the rules. When the rules change, so must the basis for decision-making. The Rules, Procedures, and Technical Regulations in this phenomenally growing and evolving sport, have exploded in two and a half years from one 13 page document to two documents totaling over 110 pages. Additionally, a third document, The Judges' Guide, an official supplementary judge's document that offers more detailed guidelines for the judges to follow while officiating, was just released for Series 5.0. Rules and Guidelines are continually being updated to reflect the latest changes in the sport. Some of the newest rules to affect the judging are:

- If necessary to render a decision during a BotBout, the Judges may consult with one or more Operators or Team members. However, during any such discussion with one Team, at least one member of the opposing Team must be present as an observer.
- If the one BattleBot was incapacitated, and a majority of the Judges agree

that the Incapacitation was due at least in part to some action of the opposing BattleBot, then the opposing BattleBot will be declared the winner by KnockOut.

- The judges can collectively disqualify a BattleBot for a safety or technical violation, if the judges reach a unanimous decision.

There are, of course, certain conduct and ethics for the judges. For one, judges are not allowed to discuss their individual scores with one another until after their scores have been transferred for final tally. There are three judges per match, but more are on the sidelines as the judges usually rotate after an hour or so, to maximize their focus, attention, and judging abilities. Each judge is required to view and pass a test after watching a training videotape that challenges their opinions and their rule knowledge on close call matches.

Although a judge's job is to be a rules expert with authorized opinions and without bias, he or she is still human (at least thus far), and there are undoubtedly plenty of ambiguous situations and controversial calls. This is the nature and excitement of this unique sport. Since all judges' decisions regarding the assignment of points are final and not subject to protest, the surest way to guarantee a win and to please a crowd (and the judges), is to go for the complete and utter Bot destruction in the arena.

Any BattleBots judge would readily admit that they prefer a bout to end in a knock out. Steven Seagal (the BattleBot, not the actor) made an impressive debut at BBIQ (far left). With its twin vertical spinning disks, Steven Seagal was able to accumulate BBIQ tournament points and crowd favoritism. After a successful BBIQ showing, the students behind Steven Seagal furthered their competitive prowess by entering the BattleBots 5.0 tournament. Using a thinly veiled disguise, Steven Seagal changed it's name to A-10 Thunderbolt and joined the AltSmooosh team. Chopper (alias The Can Opener) was first to fight the incognito martial artist. Chopper wasted no time in dismantling A-10 Thunderbolt (left). Eventually, a critical blow was dealt and A-10 Thunderbolt's power supply was torn from its chassis. The referee counted out A-10 Thunderbolt as the robot lay motionless. What had the makings of a B action movie went straight to video upon Chopper's critical review.



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Photo: Dan Loughlin, Dave Loughlin, Roy Helton

Photography by: Dan Loughlin, Dave Loughlin, Roy Helton

BREAKING DOWN THE BOT



EXCLUSIVE EXPOSURE ON THE BOTS TO BEAT

All component names and specifications have been supplied by team members.

School's out and the summer is hot for the Bots of BBIQ. Breaking Down the Bots takes a look at the engineering accomplishments delivered by the students attending the March 2002 tournament at Universal Studios, Orlando. No Robots that attending BBIQ had officially participated in any robotic tournament, so the success and failure rate had a great deal of variance between each robot. The learning curve was steep and fast; many builder were able to modify complete configurations only moments before their call to the BattleBox.

ACCELERATOR A ten member team of students and advisors put over 300 hours in the construction of this BattleBot. Representing the Plymouth North High School in Plymouth Massachusetts, Team Accelerator exhibited the utmost in BattleBots professionalism.

Two IFI Isaac 16 speed controllers. cooling fans have been removed to fit into chassis.

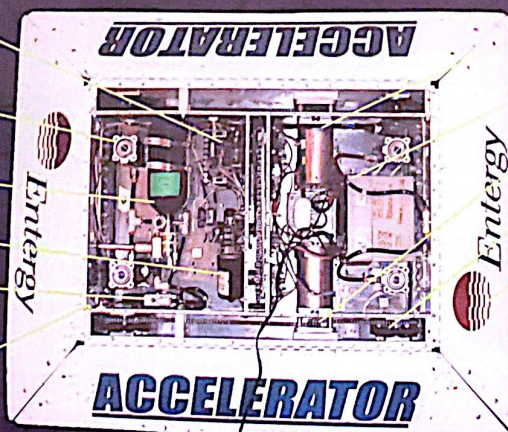
Four pneumatic lifting solenoid 1000 pounds lifting power.

Compresses air tank - Air America Paint Ball Company.

Motor off of an automatic van door.

One solenoid for firing weapon.

Two master switches to distribute current load.
Uses dimmers switches from truck headlights.



Two custom Gearless WindSmith Motors - 1 horse power each.

17amp-hour lead-acid battery.

Power train sprockets custom made.

Four Wheels - friction discs off of an Arin Lawnmower deck.

Titanium 6-4 armor.

Autodesk Inventor used for layout and design.

WEE WILLY WEDGIE As you can see, the under wears of this seasons champion are simplistic. This BattleBot was eight pounds under weight during weigh-in. The lack of weaponry was made up for by the impeccable driving skills of Jeff McLay.

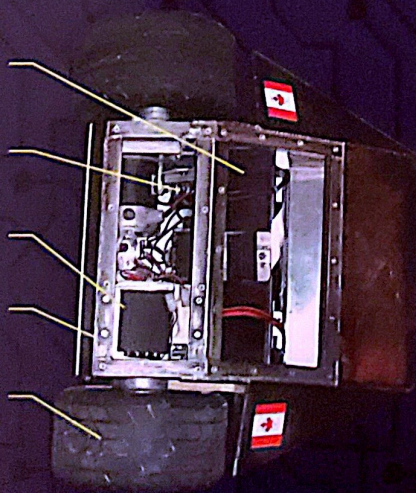
Two Hawker Genisis batteries 12volt 13 amp hour each.

IFI Issac 16 robot controller and a pair of Victor 883's.

Two 64038 NPC motors direct drive.

4130 cromolly steel.

Wheels - Parries Rain Slick go kart treads. Foam filled by American Airless.



ANGRY KITCHEN APPLIANCE

Team Angry Parent came up with an over-the-counter solution to building BattleBots. Aside from the IFI radio controll components, all components were purchased from a local hobby store.

3/16" Steel Chassis.

Aluminum paneling.

Four Trinity 550 modified motors.

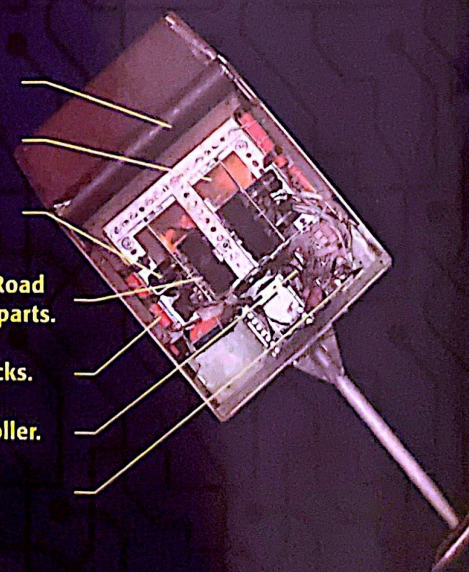
Wheels/Gearing-Off-Road remote control truck parts.

Batteries - Rocket Packs.

Rooster Speed Controller.

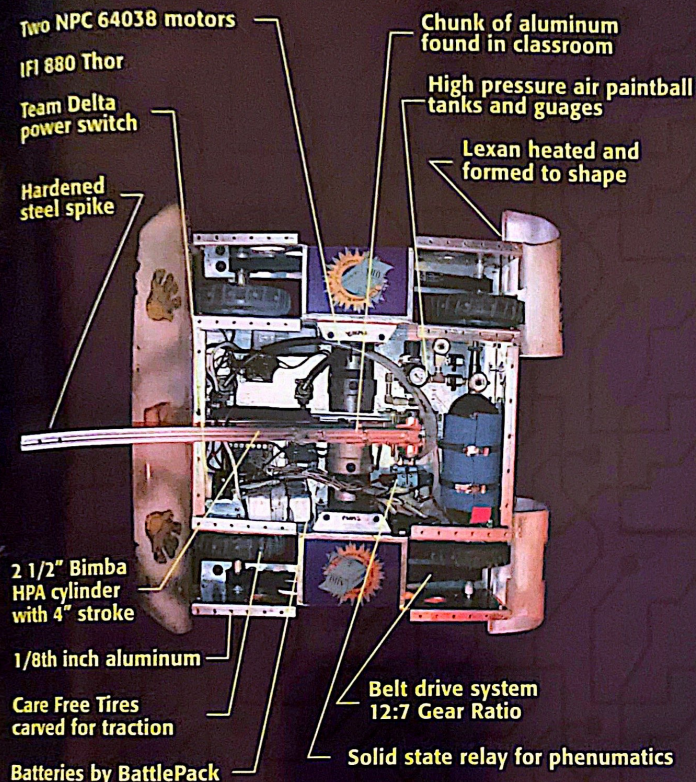
Toggle on-off switch.

Carboard and tape for layout and design.



HAMMERROYD

As seen on the cover, this engineering feat was the combined effort of large Oneida Technology Student Association Team. One of the most difficult procedures for building this BattleBot was finding a group consensus. Using a decision-making matrix, the team was able to move the project along and deliver this highly competitive entry into the BBIQ tournament.



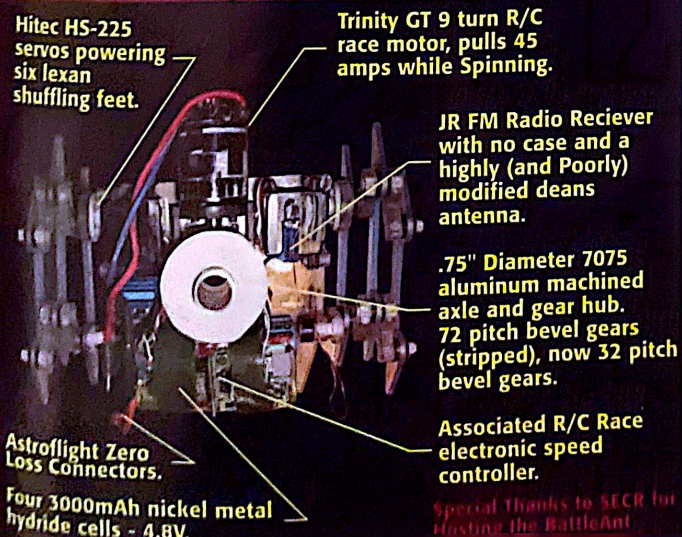
Bonus Cavity Search

DEREK YOUNG DISECTS HOSER'D
A NEW BREED OF BATTLEBOTS KNOWN AS THE ANT



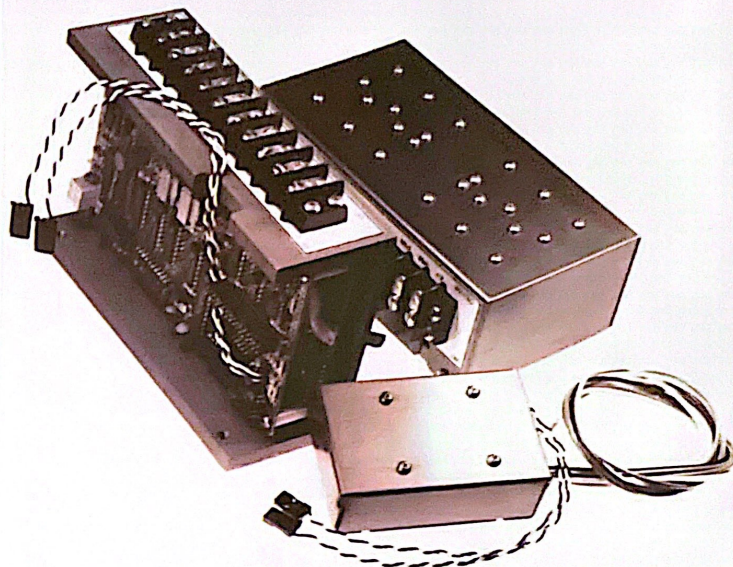
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**Editor and Chief
BattleBots Magazine
Roy F. Hellen Jr.**



Animated armored sculptures engage like gladiators from the ancient Roman Coliseum. Pause the action, lift the visors, look into the faces behind the machines. Who are these

people? BattleBots has named this rare breed of sportsmen - Builders. Builders have no singular demography or identifiable common background. A Builder is an emerging secular class, a new culture, a renaissance of The Renaissance Man. By today's standards, this can only be paralleled by the description of Extreme Thinker.

The term "Extreme Thinker" may seem cliché, but it is applicable to the Builder in many ways. The most obvious connection is to the Extreme Sports genre. A collective of Extreme Thinkers with a common passion founded BattleBots, a growth effort that founded in the beginnings of

all Extreme Sports. Though similar, the Extreme Thinker is a bit different than an Extreme Sportsman.

To identify a Builder as an Extreme Thinker is an attempt to explain the inner workings of the mind, particularly his or her approach to problem-solving. Builders seemingly approach problem-solving tasks from opposite ends of the spectrum. The detail-oriented Builder will study all aspects of the problem, and approach every minute detail methodically, whereas a more spontaneous builder will gather his tools and charge frantically into the fray, learning as he goes. In the end, both types of Builders have achieved a common goal of creation. It is this diverse way of thinking which causes BattleBots to attract every walk of life. Injection mold clean room technicians to rock 'n' roll instrument inventors, lawyers, special effects designers, goat herders, forensic doctors, and common men with common sense.

Builders are born mechanically curious. As children, they perchance took apart the phone on a regular basis or combined parts from all

their toys to create new ones. A Builder is always questioning how something works in the world around them. Often the Builder will deductively reason out machines and immediately have ideas on how to improve them.

Builders are those that have more solutions than excuses. They follow their dreams and make them happen. Builders embrace the unknown and defy that which is said "cannot be done". There is a great deal of pride to be labeled as a Builder. It is a goal that is not reached easily, but it is attainable by all Extreme Thinkers regardless of age, sex, race, color or creed.

The qualities of a Builder are in every one of us. It is a strength that can overcome any obstacle physical or mental. It is a discipline that can reason all problems. It is a religion that will shape the world around us.

The Box is Locked
The Lights are On
It's Robot Fightin' Time



**Nola Garcia
BattleBots IQ
Educational Director**



As Educational Director of BattleBots IQ (BBIQ), I am constantly faced with challenges. One of the greatest challenges other educators and I have to face is: "How do we get more girls interested in math, science, engineering, and technology?"

Four years ago, I started working on robotics with the students of Carrolton School of the Sacred Heart, an all girl's high school located in Miami, Florida. Approximately, only two percent of Carrolton graduates pursued engineering and technical fields at the college level. Some Carrolton students joined a larger, co-ed robotics team in the area. Initially, the girls placed themselves on the outer fringes of the team. At first, they were content to be observers of the design, fabrication, and

construction process. Later on however, they became more enthralled by the excitement of building a robot, from the conceptual stage to the final product, when it finally came to life and moved at the driver's will. The girls realized that they could be equal partners in the entire robot building process. Before long, the girls were working with the mill, the lathe, the drill press, the grinders, and the welders. Applying their physics and math skills to a real world situation was thrilling to them. The girls knew that they too could come up with the sophisticated programs to make the robots do complex and amazing things.

As the second year of the robot competition started, those girls, who had been on the "outside looking in" the previous year, now jumped in with both feet and became fully involved in the process. They completely constructed the robot's basic frame and drive train. They were developing the necessary skills to create and engineer a real working, competitive robot. More and more of them wanted to become drivers. Word got around their school that designing and building robots was "very, very cool". The girls started becoming the team leaders.

When the BattleBotsIQ Inaugural Competition was held in March 2002, these girls and others from around the U.S. made up 25% of all the competitors. Three of the teams that competed were all girls' teams. More and more girls around the country are finding out that engineering is exciting and rewarding. Driver Cynthia Donna loved every minute of it: "After this

experience I'm so enthusiastic to do it all over again! I've learned from my mistakes and I'm ready to make the next time even better!" Donna Mendez, a spectator at the BBIQ event commented, "Before BattleBots IQ, making a robot was an unreal thought for me. I had no previous experience. After learning so much, meeting so many new people, and experiencing such excitement and emotion, it was clear to me then, my robot must be built."

BattleBots IQ is an opening to a wonderful world of opportunities. It is a world that can take them from inner space as biomedical engineers, to outer space and the moon, Mars and beyond, and unlimited places in between. They are finding out that these careers can take them all over the world and that they will be in a position to change the world we live in for the betterment of all.

Today, the Carrolton School of the Sacred Heart is proud to say that 15-20% of their graduates are going on to further studies in engineering and technology. We have reached a time when young ladies are more aware of the joy and excitement of creating engineering wonders. BattleBotsIQ is a wonderful environment for all students to find a place for their interests to be developed into marketable skills. On top of all that it is a place where students come to create and have fun!

I truly believe that BattleBotsIQ is a part of the answer to the challenge of getting more girls interested in math, science, engineering and technology.

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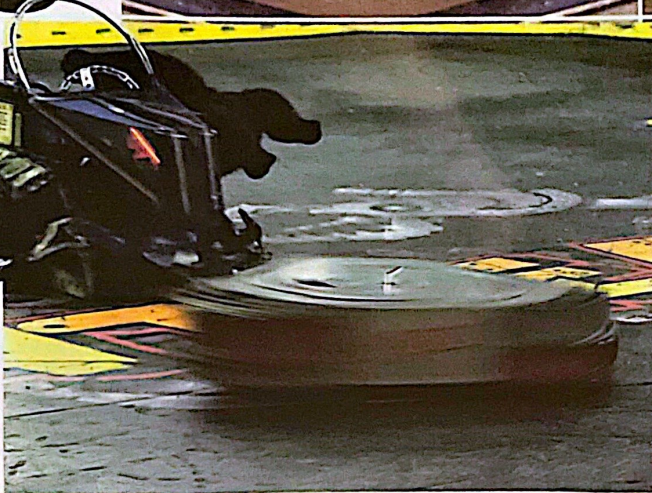
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BOT SHOTS

Daniel Longmire

Sick Mind (bottom) and Gross Negligence (top) spun up their Super Heavyweight weapons to full force and simultaneously attacked each other head on. The impact disabled both robots' weapons, which turned this bout into a pushing match. Gross Negligence pushed harder and walked away with the judges' decision.

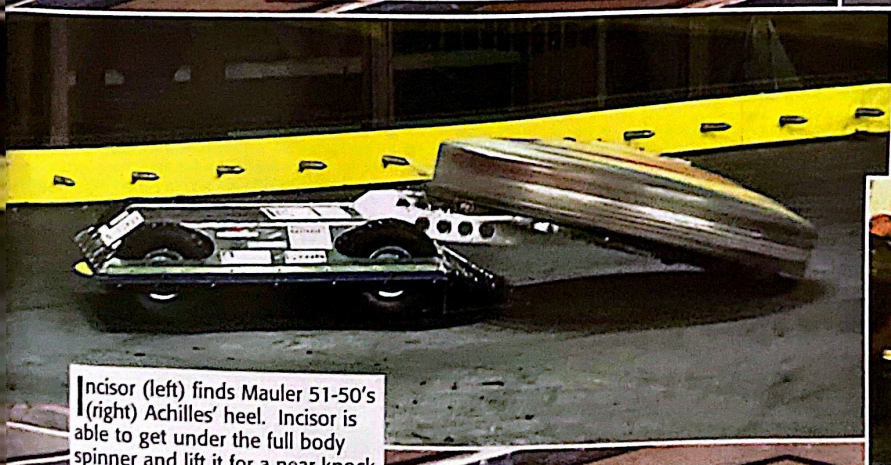
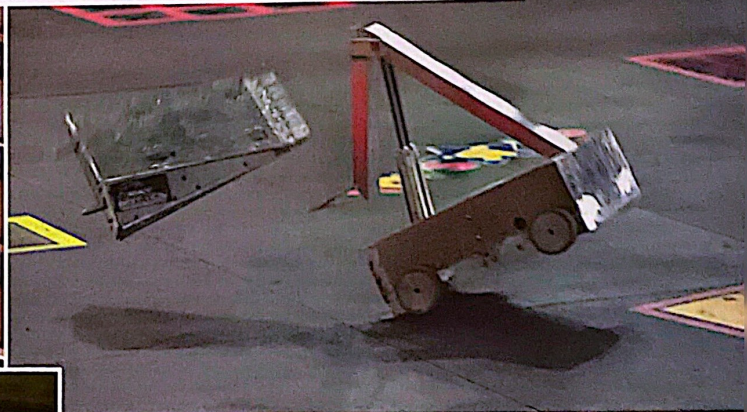
P.T. Bruiser (left) consistently fought its way through the prelims with little more than luck and determination. With "The Monkey" at the helm, hanging on for cowboy two minutes, the cavalier driving style of Team Blaze bullied its way through the preliminaries. Y-Pout (right) a Team Whyachi creation, was more than dominant during this bout. Removing P.T. Bruiser's weapon and armor, Y-Pout clearly had "The Monkey" on the run. An unfortunate turn of events caused a catastrophic failure in Y-Pout. As the last seconds ticked off of the heavyweight match clock, Y-Pout was declared immobile and knocked out.



The BattleBot Some Parts (left) and Mini Mer (right) frolic about the BattleBox in the lightweight dance of summer. Unfortunately, once the music stopped, Some Parts fell out and Mini Mer advanced through the preliminary bouts.

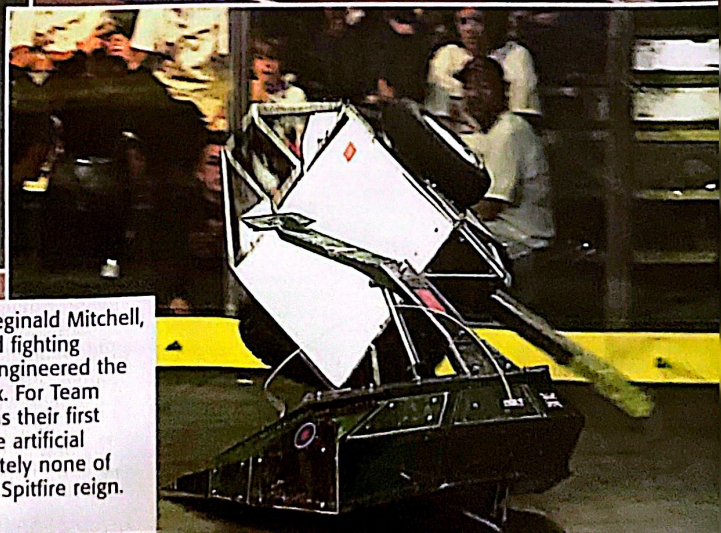


The BattleBot Little Hater (left) and Robo Master (right) collide like Mountain Rams challenging for herd dominance. Robo Master proved itself as the leader of the pack in the lightweight preliminaries.

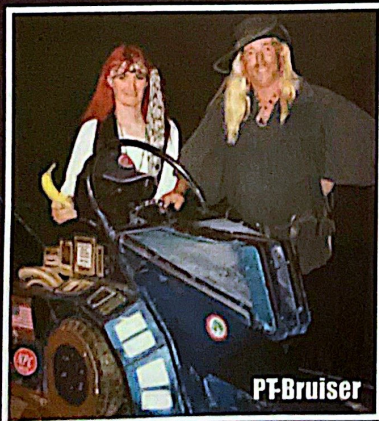


Incisor (left) finds Mauler 51-50's (right) Achilles' heel. Incisor is able to get under the full body spinner and lift it for a near knock out. This Heavyweight preliminary bout did go the distance and the outcome was to be determined at the judge's table. A controversial split decision of 23 to 22 was awarded to Mauler 51-50. Incisor was pulled from the prelims and Mauler advanced.

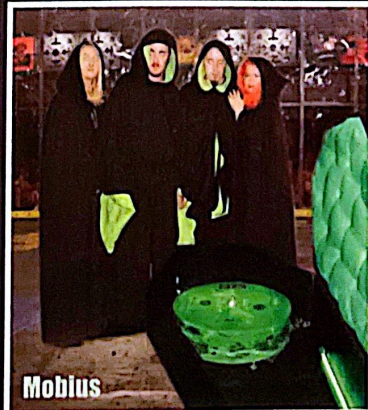
The Spitfire, originally created in 1938 by Reginald Mitchell, was one of the Royal Air Force's celebrated fighting machines. Team Lancaster Bombers have reengineered the Spitfire (bottom) to do battle in the BattleBox. For Team Nova and their creation, Golem (top), this was their first tournament. In Hebrew folklore, Golems were artificial beings made from mud and earth. Unfortunately none of Team Nova's elements could stand up to the Spitfire reign. Golem was knocked out of its first fight.



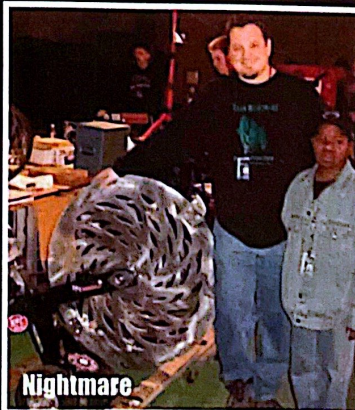
The Power To Devour



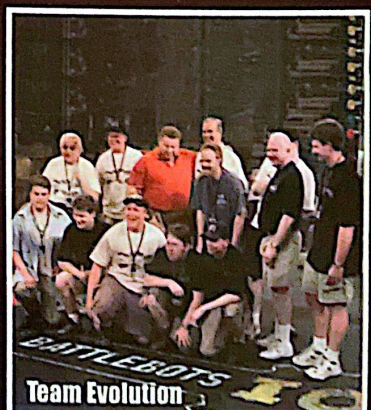
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